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(April, 1946, Vol. XXV, No. 4, Ed. B)

Contents:

"ELECTRONICS IN ENGINEERING"
by W. WILSON, D.Sc., B.Eng., M.I.E.E.

DISCUSSION ON "DIFFICULTIES AND DEVELOPMENTS IN DEEP DRAWING AND PRESSING"
by J. D. JEVONS, Ph.D., B.Sc., F.R.I.C., F.I.M.

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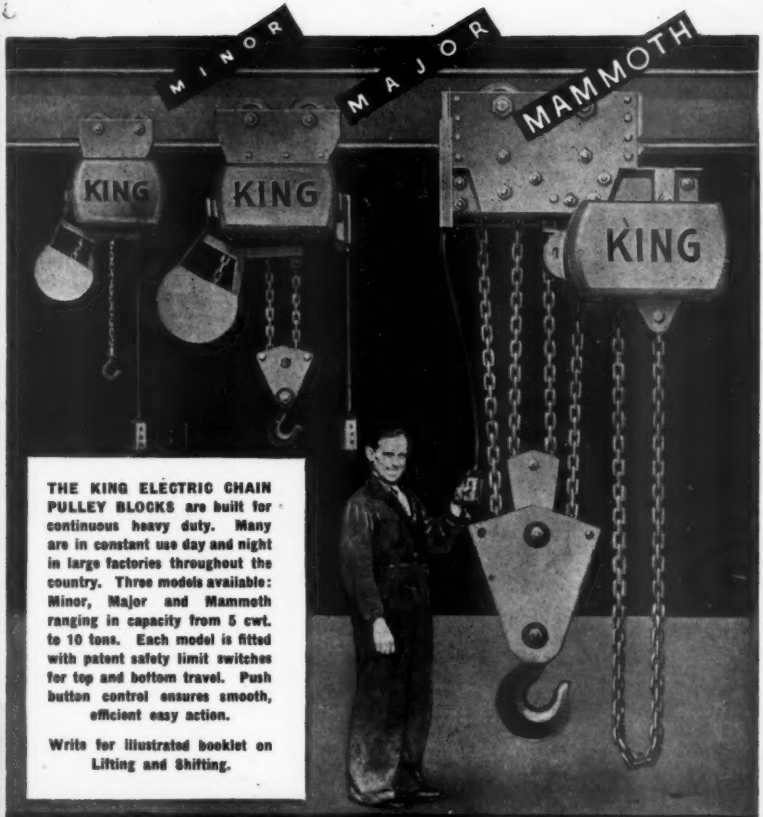

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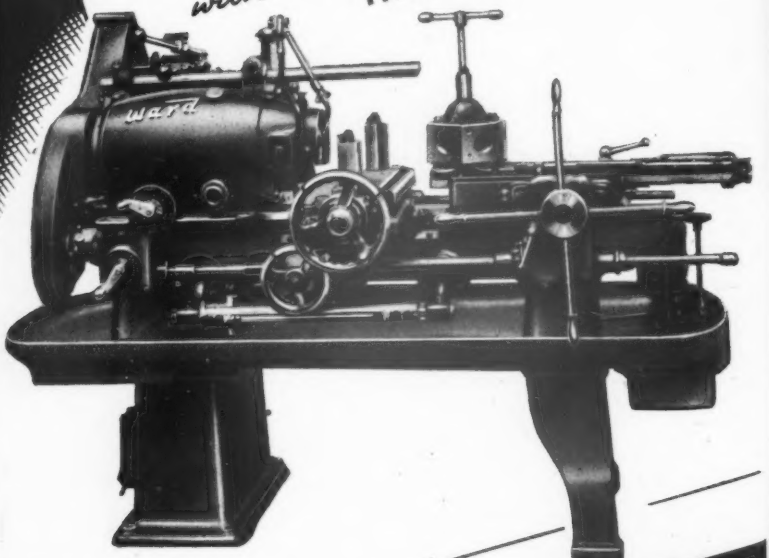

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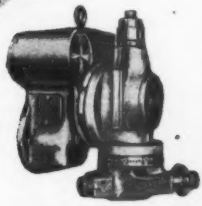

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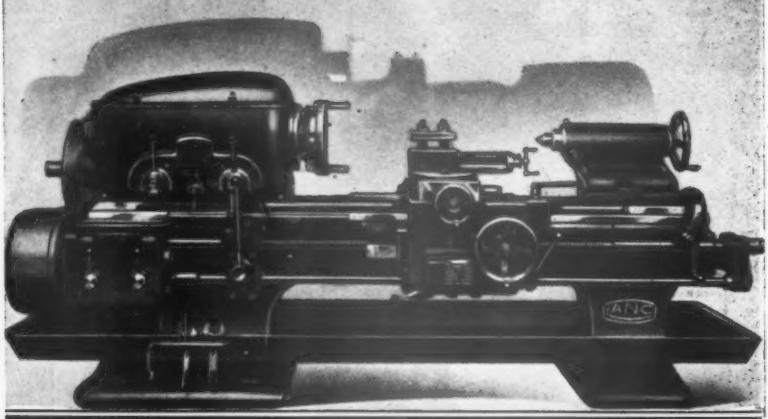

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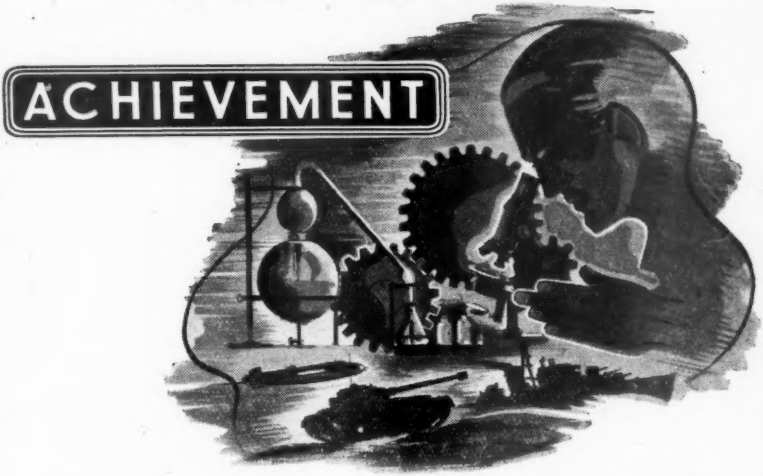

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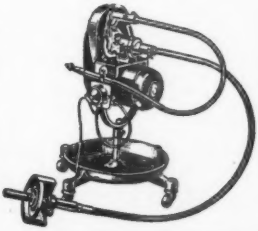

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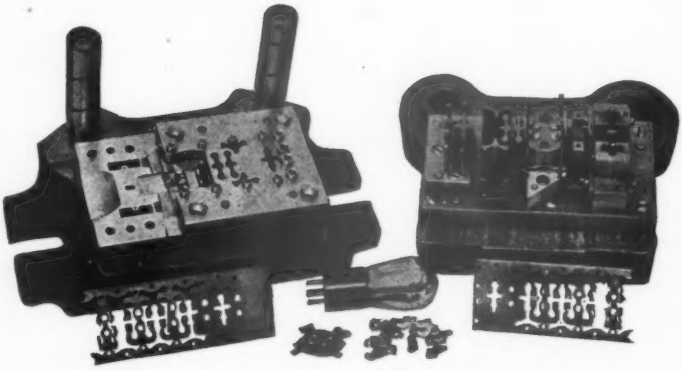

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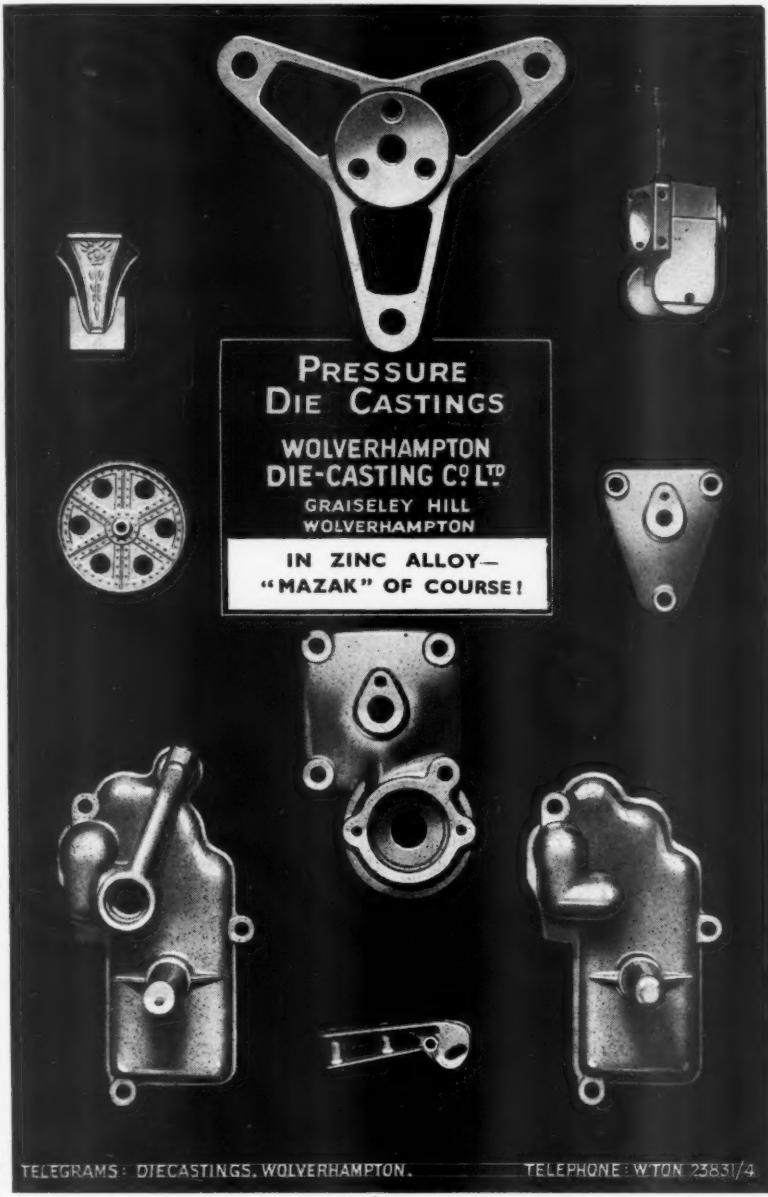
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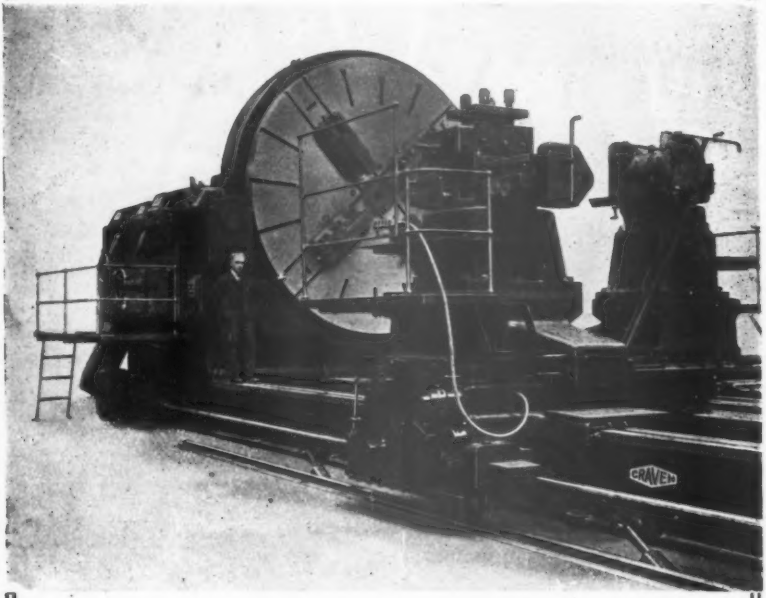

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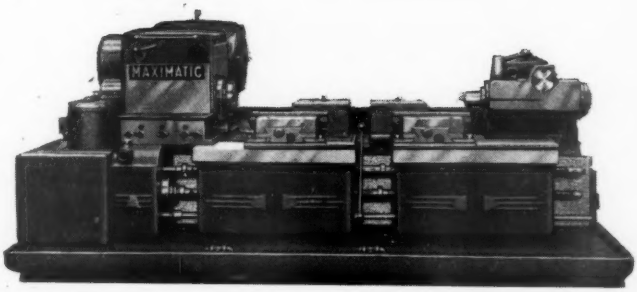

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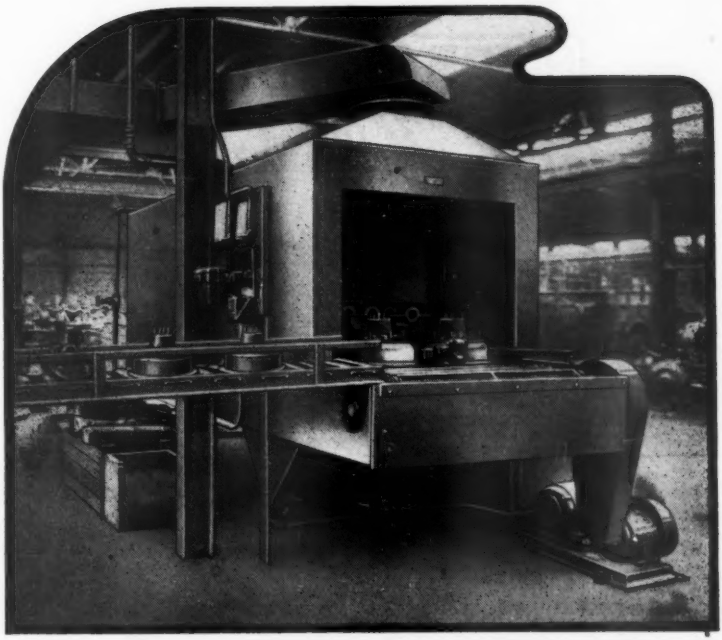

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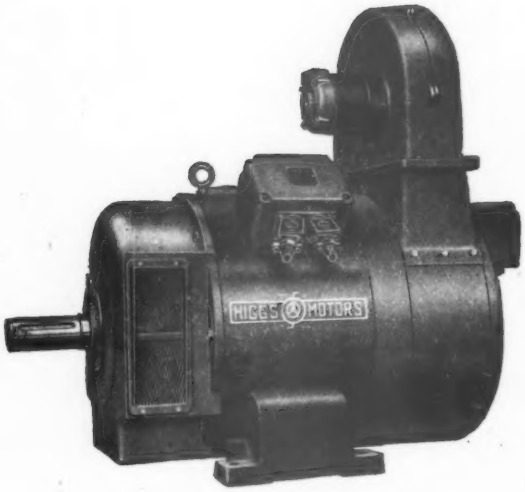

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INSTITUTION NOTES

April, 1946

April Meetings.

1st Yorkshire Section. A lecture will be given by Dr. D. F. Galloway, B.Sc. (Hons.), Wh.Sc., A.M.I.Mech.E., A.M.I.E.E. on "Surface Finish in Practice," at the Hotel Metropole, Leeds, at 7-00 p.m.

4th Leicester & District Section. The Annual General Meeting will be held at the Leicester College of Technology, Leicester, at 6-30 p.m., followed by a lecture, "Some Peacetime Applications of Aluminium Alloys," by E. G. West, Ph.D., B.Sc., and a sound film, "Fabrication of Aluminium."

6th Yorkshire Graduate Section. A "Brains Trust" Meeting will be held at the Great Northern Hotel, Leeds, at 2-30 p.m.

9th Luton & District Section. A lecture will be given by Dr. C. J. Dadswell and Mr. Muirhead on "Drop Stamping," in the Small Assembly Room, Town Hall, Luton, at 7-00 p.m.

11th Glasgow Section. The Annual General Meeting will be held at the Institution of Engineers & Shipbuilders in Scotland, at 39, Elmbank Crescent, Glasgow, C.2, at 7-15 p.m., to be followed by an informal discussion, when problems will be tabled by members.

13th Manchester Section. A Dance will be held at the College of Technology, Manchester. Full details not yet available.

17th Manchester Section. A lecture will be given by Mr. T. Norton, A.M.I.Mech.E., and Mr. Crook, on "Production of Heavy Aircraft," at the College of Technology, Manchester, at 7-15 p.m.

17th Sheffield Section. A lecture will be given by J. E. Sears, Esq., O.B.E., M.I.M.E., on "Measuring Methods," at The Royal Victoria Station Hotel, Sheffield, at 6-30 p.m.

17th Birmingham Section. Annual General Meeting, at the James Watt Memorial Institute, at 7-00 p.m. A lecture on "The Manufacture of Glass," illustrated by films, has also been arranged.

April Meetings—*Cont.*

17th Wolverhampton Section. A lecture will be given by H. W. Greenwood, Esq., on "Powder Metallurgy," at the Wisemore Schools, Walsall, at 6.30 p.m.

19th Western Section. Film Show—full details not yet available.

20th North-Eastern Graduate Section. General Meeting and Works Visit to Messrs. Bren Mfg. Co. Ltd., Team Valley Trading Estate, Gateshead.

25th Cornish Section. A lecture will be given by E. J. B. Willey, D.Sc., Ph.D., F.R.I.C., F.P.S., on "Electronics in Industry," at the School of Mines, Camborne, at 7.15 p.m.

25th Shrewsbury Sub-Section. Programme of sound films on Arc, Resistance, and Atomic Hydrogen Welding. Speaker: Mr. E. W. Harding, of the Ministry of Supply Advisory Service on Welding.

26th Lincoln Sub-Section. A lecture will be given by Mr. F. J. Everest, M.Sc., A.M.I.Mech.E., A.M.I.E.E., A.M.I.Mar.E., on "Gear Cutting," at Lincoln Technical College, Lincoln, at 6-30 p.m.

27th Manchester Section. Visit to Messrs. A. V. Roe, Ltd. Chadderton.

27th Nottingham Section. A lecture will be given by H. W. Greenwood, Esq., on "Powder Metallurgy," in the Demonstration Theatre, Corporation Gas Showrooms, Lower Parliament Street, Nottingham, at 2-30 p.m.

27th North-Eastern Section. General Meeting and Works Visit

27th Yorkshire Graduate Section. Visit to the Operating Equipment of a large cinema, at 2-30 p.m.

29th Derby Sub-Section. A lecture will be given by Mr. H. Pearson, B.A. (Oxon), on "Jet Propulsion," at the Schoo. of Art, Green Lane, Derby, at 6-30 p.m.

May Meetings.

4th Manchester Section. Visit to Messrs. A. V. Roe, Ltd., Woodford Works and Aerodrome.

11th Yorkshire Graduate Section. Annual General Meeting and "Film Afternoon," at the Great Northern Hotel, Leeds, preceded by luncheon, at 1-00 p.m.

May Meetings—*Cont.*

23rd Wolverhampton Section. A lecture will be given by R. E. Reason, Esq., on "The Measurement of Surface Texture," at the Dudley & Staffordshire Technical College, Dudley, at 6-30 p.m.

April Committee Meetings.

12th Finance & General Purposes Committee, at 2-30 p.m., in the TEMPORARY Committee Room, 36, Portman Square, London, W.1.

16th Education Committee, at 10-30 a.m., at the Queen's Hotel, Birmingham.

16th Membership Committee, at 12-30 p.m., at the Queen's Hotel, Birmingham.

— Research Committee, at 11-45 a.m., at Loughborough College, Loughborough, Leics.

Technical and Publications Committee meets every Wednesday at 5-30 p.m. in the TEMPORARY Committee Room, 36, Portman Square, London, W.1.

Until further notice, meetings of the Finance and General Purposes Committee, The Technical and Publications Committee, and the London Section Committee will be held in the TEMPORARY Committee Room at 36, Portman Square, London, W.1. All corresondence is still to be addressed to No. 10, Seymour Street, London, W.1.

Appointments Board.

At a recent meeting of the Finance and General Purposes Committee, it was decided that the Appointments Board of the Institution, which was discontinued during the war years, shall not be resuscitated for the time being.

Honours.

Since the publication of the March Journal it has come to our notice that among the recipients of the M.B.E. in the New Year's Honours List is Mr. William Bentley, M.I.P.E., to whom our congratulations are extended.

Personal.

Mr. Arthur Chilton, M.I.P.E., who has been with Head, Wrightson & Co., Ltd., for over 30 years, and is Manager of their Forgings Department, has been appointed a Director of Head, Wrightson Stampings, Ltd.

Shrewsbury Sub-Section.

On Saturday, 23rd February, 1946, Mr. I. S. Morton, of the I.P.E. Research Laboratories, Loughborough, gave an interesting lecture on "Drilling Research," at the Technical College, Shrewsbury, followed by a discussion.

Letters of thanks have been sent to Mr. Morton, and to Mr. A. Moore, Principal of Shrewsbury Technical College.

Obituary.

It is with deep regret that we have to announce the death of Mr. John Arthur, M.I.P.E.

Mr. Arthur was Secretary of the Cornish Section from its inauguration in 1938 until September, 1945, and did invaluable work in the development of the Section.

At the time of his death, he was Manager of the Pneumatic Tool Department of Messrs. Holman Bros.

Mr. Arthur will be greatly missed by his many friends and works associates in the Cornish area.

Issue of Journal to New Members.

Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

Important.

In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

DISCUSSION ON "DIFFICULTIES AND DEVELOPMENTS IN DEEP DRAWING AND PRESSING"

By J. D. JEVONS, Ph.D., B.Sc., F.R.I.C., F.I.M.

Presented to the London Section on January 17th, 1946.

THE CHAIRMAN said they had listened to an address which would appeal to almost everybody present at the meeting. Dr. Jevons, he stated, had quite rightly emphasised the fact that the closest possible co-operation must exist between scientists and the practical people in the shops, many of whom were present at the meeting and desirous, no doubt, of discussing the points raised.

He then declared the meeting open for discussion.

MR. STANLEY said he would like to know how pressure welding was applied.

MR. EGNER said he would like the author to describe the cleansing process that would be necessary, particularly with regard to aluminium, in connection with the welding described. He also asked whether oxidization over the area would prevent two surfaces joining together if they were left for any time.

MR. CLARK asked if the process of pressure welding, such as had been applied to aluminium, had been applied to metals of other kinds. He was aware of it occurring with copper, but he had never heard of it in connection with other metals.

Another point was one which he said he believed most people connected with deep drawing had encountered from time to time, both in steel drawing and brass drawing. He said he referred to the propensity that one found, particularly in drawing steel, where, in the presence of sufficient pressure or sometimes speed of drawing, a phenomenon took place whereby the lubricant, if any, became squeezed out, and there seemed to be a cold-welding taking place, something in the nature of a seizure, and the die exhibited that state known in the shops as "pick-up," with small pieces welded to it which were extremely difficult to remove.

One noticed, particularly with brass, that it frequently happened that the die very rapidly became covered with a film in a similar manner. He said he had heard from time to time that the presence of arsenic in brass was responsible, but it was curious that one batch of brass—particularly when drawing brass cups—would give a perfect shell and the die would remain in good condition, whereas

with the next batch that came along the die was covered with small pieces of brass which seemed to be tightly welded to it.

Finally, he said he would like to know if the author had come across the hydrogen embrittlement of steel shells caused by pickling.

MR. LEWIS said in connection with the last speaker's remarks it might be of interest to members if he told them how he, engaged in the production of cathode ray tubes, surmounted that difficulty. The tubes, he said, had to be produced to within three ten-thousandths of an inch, and the scoring was, of course, most important. The method by which they overcame that difficulty was to have produced a die which was extremely highly polished. The wearing of steel dies under steel was very great, and they found that when a highly polished carbide die was utilized they were able to run dies for about eighteen months without any appreciable difference in size and without any scoring, whereas with the others they were replacing them every six weeks.

They had also, at one period, to draw some brass parts in which the lips were turned inwards and had to collapse. At the same time they had to apply the season-cracking test, and they failed. He said he wondered if they had been led astray by the metal because they had to apply some form of mercury test, and he said he would like to know whether the mercury test was adequate.

MR. MARSDEN said he would like to have some information with regard to deep drawing as applied to tubes. His own experience of deep drawing in that connection concerned cups having a depth equal to about four times their diameter. He said the ordinary drawn tube was not satisfactory because it was not concentric and the ends were not co-axial.

He said he would also like to know about the optimum ratio, if such was known, of the length to diameter of one or two common metals, and if the general ratio had been increased as a result of research during the war.

MR. THOMPSON said they knew that speed may vary with different metals ; but, generally, would metal be more resistant to a high speed or would it be more resistant to a slow speed.

MR. STEELE said he would like to know the author's views with regard to shell-drawing on one press, that is where the punch followed through on two or three drawings, so that on one press and at one operation an extra long drawn tube was produced.

Also he asked whether the author agreed that the heat generated in the first draw assisted the second draw, because the heat was held in the metal and was not killed off.

MR. LAWTON said that most of the metals they got nowadays were

like emery cloth, and he would like to know if there was any liaison between metallurgists and steel manufacturers. He said people like himself were entirely in the hands of these gentlemen, and, although he knew what he wanted, did they? He said he wanted to know whether they were carrying out experiments themselves or whether they were working in liaison.

Continuing, he stated that he did not consider sufficient attention was paid to the question of drawing fluids, and he would like to know what experiments had been carried out in that connection. He asked whether the author could give him any analysis of some of the better class fluids.

Also he said he would like to know if any experiments had been carried out using cast-iron punches, and if there was any special analysis of this metal.

MR. CLARK asked whether or not it was a fact that lubricants containing soap were often difficult to remove and were, as a result, not liked. For his part he said that he had met quite a lot of woe from furnace people arising from lubricants containing soap.

M. DE VOSS said he came from the continent where the author was considered to be one of the greatest experts in existence on deep drawing. It was always a pleasure, he continued, to look forward to new issues of the sheet metal industry journals in which his articles appeared.

With reference to the very important question of crystal size, he stated that they had had quite a lot of experience in trying to get manufacturers to keep crystal size down to within certain limits.

On the question of dies, he said they had had a useful introduction to the American Graph-Mo die steel. Graph-Mo steel contained a certain amount of graphite in its make-up which, in itself, was a lubricant, and they had found an advance of something like ten times the number of draws in a Graph-Mo die than in a carbon steel die.

MR. MCLEOD said he was in the unfortunate position of being a producer of metal, but on examining the mutual standpoint with regard to the status of the industry, it was his personal conviction that British pressing and drawing could stand comparison with any other throughout the world. It had been a slow and painful process of evolution which had brought that state of affairs to its present position, because, he continued, when he commenced rolling metal about thirty years ago the plant that was in existence then was fifty years old. Gradually, however, with more severe specifications they built up effectively and improved technique until in 1938 there was opened a steel rolling mill which had given a quality of metal not hitherto available.

He said he could give assurance that there had been quite a considerable amount of indivdual research in steel, and very close liaison with those who used that material. In his experience, he added, the rolling mill people were very happy to co-operate very fully, and people in the industry should take advantage of the opportunity afforded to gain that knowledge which was available at the rolling mill. Also, he continued, at the end of last year was formed the British Iron and Steel Research Association under Sir Charles Grieve, with the object of collating all research throughout the country and instituting new research in order to make the knowledge gained thereby available to the industry generally.

With regard to those people who designed and made tools, he said he considered that the very fine exhibition held in London a short time ago was adequate testimony to their skill and ability, and there was absolutely nothing to fear in that connection.

Also, he continued, there was the person who had to cope with untold difficulties and problems, the person who worried about why certain things happened and endeavoured to find a solution, namely, the works metallurgist, to whom the industry owed a very big debt of thanks.

On the subject of stress-corrosion, he said, their knowledge had advanced throughout the world. During the war he said he had a cable from America requesting all the knowledge available in this country on that subject to be forwarded, and Dr. Jevons was one of the people who collaborated in devising tests for this.

He mentioned the fact that in 1940 a paper was given to the Iron and Steel Institute on the subject of Titanium Steels, which was neglected and overlooked. It was published in Germany and again in America, and he had received a letter from America pointing out that work in that connection was originally started in Great Britain.

MR. E. S. LLOYD, replying on behalf of Dr. Jevons, the author, said with regard to the application of pressure welding, the parts were not heated up to the melting point of the metals being joined. Under pressure, with the application of heat, one did get crystallisation, that is, the actual formation and union of crystals across the interface. With aluminium in particular it was possible by the application of pressure to get a join at a temperature of 400–450°C. or even lower, despite the fact that the melting point of aluminium was 658°C. The greater the pressure the easier was the growth of crystals across the interface between the two parts. People engaged in spot welding would have had occasions when, despite the fact that examination showed that the application of pressure and heat had not been sufficient to form the usual molten lozenge at the interface, but had been only sufficient to cause crystals to grow or merge into

one another across this interface, a joint of nearly the same strength as that given by a proper, *i.e.*, molten, spot weld had resulted.

With regard to the question raised by the second speaker, he said oxidisation of the surface, of course, was one of the principal factors which prohibited the growth of crystals across the joint. Aluminium did form an oxide film which was most resistant, and it was often necessary to remove it before applying pressure. In the case of aluminium it was sufficient to rub the surface with emery immediately before carrying out the pressure welding operation. It had also been established that, unlike spot welding where, of course, it was essential to remove the oxide film, pressure welding was less sensitive to surface condition. In addition to pressure welding being used with aluminium, it had also been used with brass and copper, but on a laboratory scale only.

In reply to the point raised concerning the " picked up " state of the die, he said that although scientifically it was an interesting feature, it was, nevertheless, an unwelcome one in the industry. It often happened in the press shop that if the surface of the die was not perfectly smooth, and if there were slight excrescences on the surface, when the sheet was drawn the film of lubricant was broken down and one got metal-to-metal contact. That was why an important feature of a lubricant was its film strength. Rough surface of the parts or excessive drawing speeds could break down the film of lubricant, resulting in metal-to-metal contact and actual seizing.

With regard to the die becoming covered with a film, he said that that must be cleaned off immediately, otherwise it rapidly became worse and the die was soon scrapped. He said he had not come across the point raised about arsenic being responsible for causing this " loading " with brass, but it was a point of interest and one which he would be glad to take up.

He said he had intended to mention the fact that when dealing with this pick-up with steel, one way of overcoming that difficulty was to use chromium-plated dies. The usual procedure was not to plate on to steel in a fully hardened condition because there was a risk of cracking. The hardness should be about 46–48 Rockwell C before plating, and a common practice was to plate to a depth of one-thousandth of an inch.

In connection with the season-cracking test for brass, he stated that the purpose of this was to show whether the parts were likely to fail in service. It consisted of immersing the parts in a solution of mercurous nitrate, when, if they were in a considerable state of stress, they often cracked spontaneously. In fact you could sometimes hear them. If, after a period, they did not show any cracking, it was presumed that the internal stresses were of a sufficiently low magnitude not to be serious.

The exact significance of the mercury test, he continued, was

controversial. It did not reproduce the precise formations of cracks one got in season-cracking which occurred during service, but most specifications did call for that test, and, although its results might not be identical with those produced by true season-cracking, it did give some indication of the magnitude of the internal stress in brass. The only way of ensuring that the parts did not fail under the mercury test was to give them a low-temperature anneal in the region of 300°C. for three-quarters of an hour. This treatment, although it reduced the magnitude of internal stress to a safe degree, did not soften the material.

It had been found, even when the mercurous nitrate solution was weakened considerably, that types of cracking different from true season were still obtained.

With reference to the question concerning the hydrogen embrittlement of steel, he said that at one time they had had a lot of trouble owing to hydrogen embrittlement in connection with smoke bombs. It was particularly noticeable in harder materials. Hardened spring steel was more susceptible to that form of cracking than mild steel. It was likely to cause trouble with low carbon steels which had been hardened by cold-working to a figure of 260 V.P.M. or more.

In reply to the question relating to the formation of tubes, or deep cups, by deep drawing, he stated that because of the low work-hardening capacity of aluminium, it could readily be deep-drawn into a long tube, often without interstage annealing. He could also call to mind a fairly deep steel container which was deep-drawn quite easily when a solid type of lubricant containing zinc oxide was used. There were also quite efficient types containing graphite. The disadvantage of these substances was the difficulty of their removal before annealing. A familiar example of a deep-drawn tube was the bicycle inflator tube. There were, naturally, practical difficulties owing to the length of stroke of the press; hence, if a particularly deep draw was desired, it was often better to use a rack and pinion press or a hydraulic press rather than a crank press.

The ratio of length to diameter was, really, a matter of how many interstaging annealings could be given.

With regard to the question raised concerning the speed of drawing, he said that speed was one of those things about which more precise knowledge was badly needed. In general, deeper draws could be obtained with slow speeds than with high speeds.

Continuing, he said that the triple-drawing scheme mentioned by Mr. Steele was a very good one, and one that had been used for many years in the hardware industry. It was capable of giving three pressing or drawing operations in the time normally taken by one. It was Dr. Jevons's belief that the heating which the pressing

acquired during the first draw assisted the following draws very substantially, and probably explained, at least in part, why remarkably deep draws could be obtained in double or triple action presses used to give a follow-on drawing sequence.

Having regard to the question raised by one speaker concerning the liaison between suppliers and users of metal, he said he thought that Mr. McLeod had already dealt adequately with that aspect. It was true that the man in the shop knew that one lot of metal did what he expected of it, yet immediately following that another lot of metal, stated to be precisely the same, came in, but instead of obtaining sound pressing he obtained failures.

As a result of the work done by Dr. Jevons, he said they had had many discussions with suppliers, who, they had found, were most anxious to share the knowledge which was forthcoming with regard to steel, particularly the internal structure of steel which, unfortunately, at the present time was not covered by any of the relevant British Standard specifications.

With regard to the queston of lubricants, he said that was a subject on its own and was too wide to discuss in a few words. However, he continued, a good lubricant which he recommended could be made by mixing 5 lb. of curd soap and 5 lb. of wool fat (Lanoline) with 6 gallons of soft water warmed to a temperature not exceeding 135°F. That was the concentrated solution. If to that concentrate 15 gallons of soft water were added, it was usually found to be suitable in that condition for steel. For brass a further dilution might be found necessary. It must be pointed out, he added, that although that solution might be usefully employed for relatively light pressings such as headlamp bodies, it was not recommended for the heavy drawing of steel, such as tubular formations, which generally required a more viscous type of lubricant.

Regarding cast iron for tools, he said that quite a number of types of iron had been used. One could use an ordinary grade of cast iron having a good close grain, or one could use what was known as the inoculated type of cast-iron, which was of better quality. One could also use an alloy type of cast-iron and, lastly, there was the most recent addition to the types of cast-iron, namely, the acicular type.

As to prolonging the life of steel tools and avoiding "pick-up" one useful method was to chromium-plate. Another was to nitride steels which responded to this treatment, but some of the popular nitriding steels were found to have an insufficient core hardness to prevent the nitrided skin "caving-in" under heavy pressure. High-carbon high-chromium steels often proved very successful because they could be heat-treated to give a core strength of well

over 100 tons per square inch and then nitrided to give a very hard surface skin which would take an excellent finish.

Regarding "Graph-Mo" graphitic steel, he had had no practical experience of this new tool material. Like M. de Voss, he had read about it in American technical literature with considerable interest.

He said the answer to the question: Were lubricants containing soap often difficult to remove, was yes, they were, and far more attention should be given to choosing a lubricant which could be easily removed from the work.

Regarding the question of crystal size, he said that that was a most important matter, and one which ought to be controlled by specification. In the instance of his own firm, several of the large suppliers did supply both steel and brass to crystal size specifications laid down by Dr. Jevons.

A vote of thanks accorded to Dr. Jevons, the author of the paper, and to Mr. Lloyd was carried with acclamation, and the meeting then terminated.

ELECTRONICS IN ENGINEERING

By W. WILSON, D.Sc., B.Eng., M.I.E.E.

Presented to the Leicester Section, 11th October, 1945

There must be very few engineers who have not come across at least one or two of the recent applications of Electronics in some branch of their profession, while most already realise that its employment is destined to increase very greatly after the conclusion of hostilities. But as far as its application is concerned, it is a novelty, and is usually considered to be the most modern branch of electrical engineering. Most scientific people are aware that it has undergone very great development in the hands of the armed forces and their technical advisers ; and are looking forward to the utilisation of the new powers which it has proved capable of conferring upon existing apparatus, so increasing their efficiency and economy as to offset much of the wastage and losses of warfare.

There is much to gain, therefore, by recalling what electronics has done in the past, and what it is likely to do in the future. (Now a good case may be made out for stating that electronics is an old principle, known and utilised quite early in electrical history, and accorded its present attention merely because segregated workers have begun to compare notes and to make use of one anothers' discoveries. At such a juncture as the present, it is a good thing to pause for a few moments and take a broad survey of the whole position, to note down all our assets, the use we have made of them and the opportunities that lie open to us in the near future.) Such a stock-taking is attempted below, accompanied by an appreciation of what electronics is doing at the present time.

Past Development.

When one traces the history of quite a number of inventions, one is surprised to find that they have been achieved by two or more independent workers travelling along quite different routes. In some cases it would seem that if this duplication had not occurred, the new scheme would not have secured enough support to be adopted. In others, two or more embodiments of the same idea have pursued a parallel course in different phases of the subject, until someone, taking a wider view than his predecessors, discovered that they were essentially the same principle or piece of apparatus. This latter has been the case with electronics, for to arrive at its origin one must go right back to the first beginnings of electrical engineering. Now

electric power (as distinct from small-current applications of electricity) was in its early days applied for one main purpose, *i.e.*, the production of light. Between 60 and 100 years ago there were, and still are, three types of electric lamp, namely (in order of appearance) the arc, discharge tube, and incandescent filament. The three lines of development that started from these three discoveries are set out in Fig. 1.

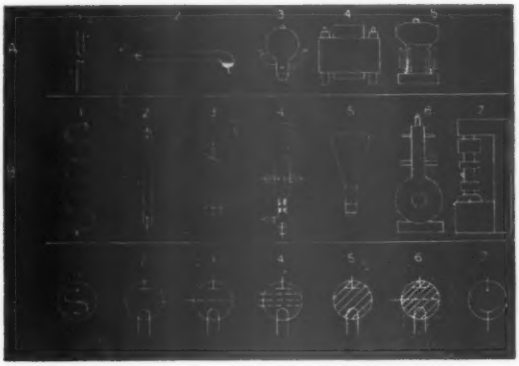

FIG. 1. Electronic Development (*courtesy of Beama Journal*).

(*a*) *The Electric Arc.*

The arc (1) was produced when two conductors energised at about 40 volts or more were touched together and then withdrawn through a short distance. Burning of the electrodes was minimised by enclosing the arc, and prevented by evacuating the enclosure ; and hence the mercury vapour arc (2) came into existence. It was soon found that this lamp possessed rectifying properties, and the design was modified to serve purely as a rectifier (3). The continuously evacuated steel tank form (4) followed, and more recently the gap between (3) and (4) was bridged by the pumpless steel tank rectifier (5).

(*b*) *The Discharge Tube.*

It was found not very long after electricity was first generated by frictional machines that it could produce a luminous discharge in an evacuated tube (1). No great amount of light was emitted by the small " Geissler " tubes, but it was found possible to modify the colour and intensity by varying the residual gas and by the use of fluorescent coatings on the inside surface. The Moore tube (2), containing nitrogen, enjoyed a short life round about 1908 as an

illuminant, but the principle was to revive with complete success a quarter of a century later as the fluorescent lamp. Crookes investigated the nature of the discharge, and designed the tube bearing his name (3) by which "cathode" rays, and incidentally X-rays, were generated. A further development by J. J. Thomson in 1897 gave the cathode ray oscillograph (4), in which the beam was recognised as a stream of electrons. The industrial form of the present day (5) is not very different from his except in details, and the large metal-tube continuously evacuated model (6) contains much the same parts with a few additional refinements. The electron microscope (7) is virtually a cathode ray tube with three carefully designed electron lenses instead of one or two of more primitive form.

(*c*) *The Filament Lamp.*

The incandescent lamp (1) may be said to start from the carbon filament type made by Swan in 1879. It was soon observed that carbon particles were discharged from the filament to the inside of the bulb away from the negative end; and that the positive limb cast a shadow, *i.e.*, a thin stream free from carbon. Fleming recognised this discharge in 1904 as an electron stream coming from the more negative part of the filament, and embodied the principle in his hot cathode valve (2). The third electrode, or grid, was added by de Forrest (3), and more grids by various workers, to produce, for example, the pentode (4). By inserting a trace of gas or mercury vapour into the vacuum, the gas-filled rectifier diode (5), and G.F. triode or thyratron (6) were evolved, capable of much higher efficiency and greater current-carrying powers than the vacuum types. Finally, a diode with a light-sensitive cathode varies its resistance to current flow in proportion to the light intensity, and constitutes the photo-electric cell (7).

First Appearance of Electronic Effects.

When the course of each of these developments is examined, the surprising fact emerges that definite electronic action appeared at the outset, not in one, but in all three cases. In the first, the open arc is due to a stream of electrons; or if the term "electronic" is restricted to action in a vacuum, it is indisputably applicable to the mercury arc. The Geissler tube is an electronic device beyond all question; and it was the electron flow in the earliest form of incandescent lamp that directly led to the first thermionic valve.

A further striking observation is that in the first and third series, A3 is to all intents and purposes the same device as C5 multiplied in size by 10^4 or 10^5. The chief difference between them is the means for starting the discharge, namely, by a mechanically moving electrode or "igniter" in A3 and by the hot cathode in C5. For years it does

not seem to have occurred to electronic engineers that in the mercury arc rectifier there already existed a long established and highly successful valve ; nor did rectifier designers recognise in the valve a kindred device from which valuable lessons were to be learnt. Such narrow-aspect development is unfortunately the rule rather than the exception in scientific progress. If, however, there had been an investigator or a group of workers who had recognised from the beginning the similar electronic basis of these three lines of research, it can be regarded as certain that the present stage of development would have been anticipated by some and perhaps by many years.

With the exception of the recent B7, the three lines have been terminated in the diagram at the positions reached in practice about a decade ago. At about this time, realisation at last came that all belonged to the same family, and from then onwards the most notable progress has largely taken place by applying to apparatus in one series features that have been found successful in another.

Recent Advances.

Of the developments in electronic apparatus that have taken place during about the last ten years, the following examples may be selected for special comment.

(*a*) The grid-controlled mercury arc rectifier.
(*b*) The inverter.
(*c*) The ignitron.
(*d*) The magic eye.

(*a*) *Grid Rectifier.*

The first of these examples conferred upon the power rectifier the advantages of grid control as used in the thermionic valve. It enabled A3, A4 or A5 to make the same advance as that by which C5 became C6. Instead of being merely a device for converting A.C. power into D.C., it can now function as an automatic switch, instantaneous in its operation, and capable of controlling the R.M.S. value of the current according to any desired scheme.

A good example of a sealed-off steel-tank rectifier is shown in Fig. 2. The control grids are added to this apparatus by inserting small insulating bushes in the anode arms not far from their ends.

It may be well to recall briefly the effect of a control grid in an electronic device, and to differentiate between the D.C. and A.C. cases. In a hard tube, such as the triode C_3, which is primarily intended for use upon D.C., the grid voltage continuously controls the anode current ; the latter starting, fluctuating, and ceasing according to the same series of changes as the former. In other words, the grid *modulates* the anode current. But in the gas-filled triode C_4 the grid can simply initiate the current and is thereafter

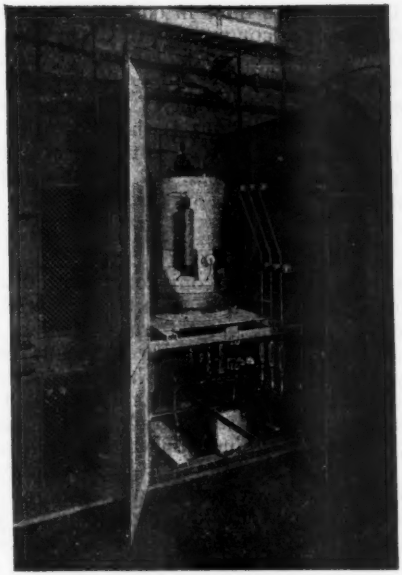

FIG. 2. Pumpless Rectifier (*courtesy of G.E.C., Ltd.*).

powerless to vary or stop it. It has thus become merely a *trigger* device.

When used on D.C., the gas-triode can produce a square-fronted current, persisting at full value until it is interrupted by external means. On A.C., the grid causes the current to start at any point in the cycle, and to continue the wave until the next zero point is reached, whereupon the discharge ceases until it is again initiated in the same manner. Thus with the aid of an auxiliary valve, or other device for applying the triggering impulse at the desired point in each half-cycle, the duration of each current pulse can be regulated, and with it the R.M.S. value of the current.

This is then the change that has been effected in the capabilities of the mercury arc rectifier by the addition of the grid; and a comparison may now be made between the respective capabilities of the three triodes. First, the gas (or more usually vapour) filling has conferred upon C_6 (as upon C_5) a greatly reduced voltage drop, and therefore a lower loss, higher efficiency, and greater current-carrying capacity. Secondly, A_3, A_4 and A_5 also possess the above

advantages. Thirdly, these three in comparison with C_5, and the grid-controlled rectifier as compared with C_6, have in their mercury pool the great advantage of an indestructible cathode, which is usually a decisive factor in power engineering. In the author's opinion, however, the greatest value of a comparison between the A and the C types of apparatus is the proof that the valuable attributes of the thermionic valve are not necessarily confined to circuits carrying a few μA or mA, but can be extended to heavy current engineering.

(*b*) *Inverter.*

The possession of a grid, in conjunction with a suitable transformer, also enables A_3, A_4, A_5 or even C_5 to reverse its functions, *i.e.*, to convert D.C. to A.C. at a frequency set by a pilot wave applied to the grid. There are a number of circuits for the purpose, involving either two gas-filled triodes which conduct alternately, or a single triode, exemplified by the circuit shown in Fig. 3. For isolated equipments the pilot wave would be supplied by a tuned circuit (R_1C_3), acting in conjunction with a feed-back from the output (C_1); but the need does not arise in the case of an installation feeding into an existing supply main.

Inverters may be designed embodying gas-triodes or grid-rectifiers, and thus may be given outputs having a very wide range as regards

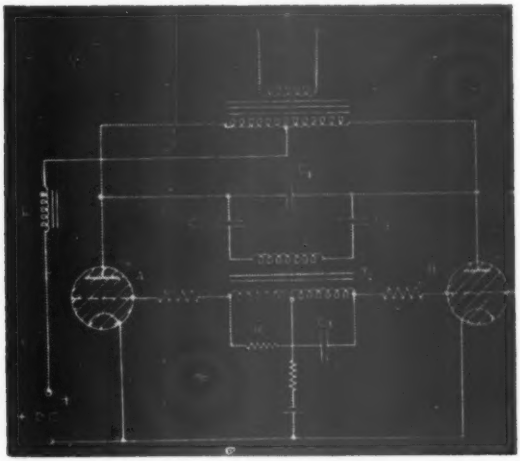

FIG. 3. Inverter Circuit (*courtesy of Beama Journal*).

power and frequency"; in addition to conventional ratings, they may be for high frequency and heavy current.

(*c*) *Ignitron.*

The chief drawback of the pool cathode in the mercury arc rectifier is the necessity of striking the arc in order to start the discharge, for which an auxiliary moving electrode is used in the standard design. A static and therefore a simpler method was discovered by Slepian in 1931, in the shape of a carborundum-tipped electrode dipping into the surface of the pool as indicated in Fig. 4. When a current of about 10 A. at 150 V. is applied to this electrode, a cathode spot is instantaneously formed on the mercury and the anode current reaches its full value. The new electrode therefore performs the functions not only of an igniter, but also of the grid in other valves.

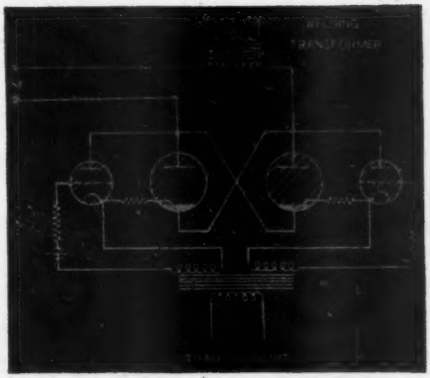

FIG. 4. Ignitron Circuit (*courtesy of Beama Journal*).

Since a definite current is required to start the arc, as compared with a voltage in the case of the valve-grid, a pilot valve in the form of a gas triode is usually required in cascade with the ignitron. This combination is capable of switching heavy power currents in accordance with an exact timing sequence.

(*d*) *Magic Eye.*

As an example of the combination of the A and B series, the magic eye is worth a brief mention. The similarity between the cathode ray oscilloscope (B4) and the triode (C3) was recognised some years back when in spite of its shape the cathode cylinder was first termed

the "grid." This was followed, however, by the location of the two elements in the same bulb, as shown in Fig. 5, the triode acting as an amplifier for the oscilloscope. The latter is simplified by the use of only a single deflector, and by the deposition of the fluorescent screen upon the ring-shaped anode. Apart from its original function of tuning indicator for radio sets the magic eye is a useful detector for bridge measurements, and may also be used as a voltmeter.

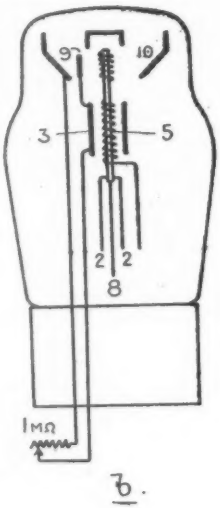

FIG. 5. Magic Eye (*courtesy of Beama Journal*).

Applications and Possibilities.

It must be evident to anyone who surveys the subject with an open mind that there are no switching, controlling or frequency-conversion operations which may not in the future be carried out electronically with greater effectiveness and economy than by the present methods, whatever the kW or kVA capacity. Some examples of what has been done in this direction will be given, together with forecasts as to what is possible in the near future; but it is advisable to begin with a note as to the most frequent objection that is urged against electronic operation.

Durability of Electronic Devices.

When an electronic method is proposed to the average power engineer, he is almost certain to remark that the use of glass valves and flimsy metal components would be quite out of place, owing to the risk of fracture of both and the short life of the valves. The following comments are therefore in order:

(1) The valves need not be of glass. In Fig. 1 items A_4, A_5, B_6 and B_7 are of metal, as may be any from C_2 to C_6.

(2) In any case, the glass valves do not suffer from insufficient robustness. No warship, bomber or fighter plane could go into action without a very numerous equipment of valves, and they meet all requirements.

(3) It is well known that the glass cathode ray tube is far less liable to damage than any type of voltmeter or ammeter, both on account of the negligible risk of harm through over-deflection, and the absence of a mechanical bearing or suspension.

(4) The prevalent idea that the average life of a valve is 1,000 hours is a survival from the days of the first battery-type units for radio receivers of over 20 years ago, which were designed in the first place for maximum economy in battery power. Modern valves can be relied upon to do duty for about 10,000 hours, and many of practically every type actually last twice as long.

(5) There need be no components in an electronic equipment more flimsy than, for example, an average tumbler switch.

Large Scale Electronics.

An indication as to the possibilities of applying electronic methods on a large scale can be obtained by considering the capabilities of a modern radio receiver. Probably everyone will agree that what has been achieved in the ordinary set has exceeded our expectations of a quarter of a century ago in an almost miraculous manner. Yet there is no real reason why any of the sections of such a set—oscillator, amplifier, frequency changer, rectifier, automatic volume control, and the rest—should not be designed on heavy current lines and thus provide the same performance in heavy engineering. As has already been shown, the rectifier stage has been so functioning for many years ; while the basic stage, *i.e.*, the oscillator in the case of a transmitting set or a receiving set with reaction, has also undergone the same development. This will be described under the next heading and illustrated in Fig. 6.

High Frequency Heating.

Present methods of large scale heating, by radiation or convection, all suffer from the serious objection that the heat can only be applied to the outside of an article, and has to work its way to the inside by the establishment of a heat gradient that is often sufficient to damage the exterior, as for example, when bread is baked. Further, there is no satisfactory method of directing the heat exactly to the place where it is wanted, in the event of only part of an article requiring treatment.

Non-metallic substances also are bad thermal conductors, and the time required for the heating process is many times as great as would be needed if percolation from the outside were not essential.

All these drawbacks are obviated by H.F. heating. If the article to be treated is a conductor, it can be acted upon by a coil that will make it the short-circuited secondary of a transformer operating at a frequency of say 1 to 10 kc/s. If it is an insulator it can be placed between two electrodes that will cause it to function as the dielectric of a condenser stressed at, say, 1 to 20 mc/s. In the first case the eddy currents, and in the second the dielectric losses, will generate heat in the material itself, without any connection to the

FIG. 6. High Frequency Generator (*courtesy of G.E.C., Ltd.*).

circuit being necessary. The result is a saving in time that may be enormous.

Relatively low frequency current can be produced by rotating alternators ; but in the majority of cases a valve generator is used, exactly like the oscillator stage of a wireless set on a heavy current scale. An important factor in connection with future applications is the overall efficiency of useful heat production, which is already slightly over 50 per cent., and this should be compared with that of other heating methods. It is interesting to observe how closely the

apparatus in Fig. 6 resembles a radio receiver stage on a greatly enlarged scale.

The apparatus itself is at present somewhat expensive ; but there are many cases where the great advantages already stated will much more than justify the additional first cost. Such worth-while applications are the drying of timber, the cementing of laminated wood, the heat-treatment of metal parts such as gear-wheels and localised portions of shafts, the heating of outer surfaces by taking advantage of skin effect, and many similar requirements.

An example of capacity current heating will serve to illustrate the advantages of the high frequency method. Suppose that a block of wood 6 inches thick has to be raised to 100°C. without the temperature of the exterior exceeding 150°C. ; this being a typical requirement in connection with the manufacture of aircraft propellers and other glued components. Then assuming the block to be initially at 15°C., and the outside faces to be maintained continuously at 150°C., a period of nearly 4½ hours will be required for the temperature in the middle to reach 100°C.

If however the capacity current method be applied as indicated in Fig. 7, the whole mass of the wood will heat up uniformly to the required temperature in 19 minutes, and that without requiring that any portion shall be at a higher temperature. In fact, the outer faces of the wood are usually at a slightly lower temperature than the interior, owing to cooling *via* the electrodes, and in consequence these are often independently heated by the resistance method to overcome the effect. The recent developments in polymerising glues, containing bakelite or urea-formaldehyde, which do not require the driving off of a solvent, but can be solidified in a few minutes by the application of heat, goes hand in hand with high frequency heating.

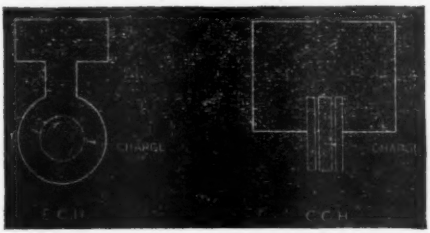

FIG. 7. High Frequency Heating Circuits (*courtesy of Beama Journal*).

Resistance Welding.

There is no need to describe the greatly increased use that is now being made of welding, not only for thick sections, but especially for

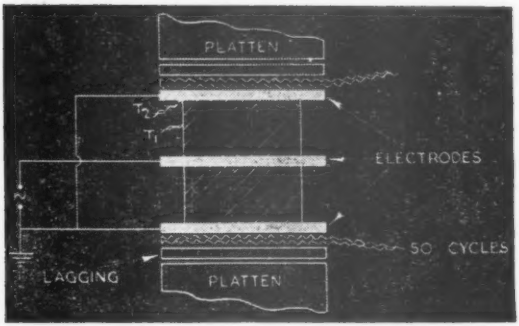

FIG. 7a. Electrodes (*courtesy of Beama Journal*)

thin sheets. The latter are being quickly joined by accurately timed applications of heavy current between massive electrodes, forming detached welds by virtue of the resistance between the surfaces.

The most effective method in use to-day for controlling the current is by means of large gas-filled valves, ignitrons being very suitable for such work. They are generally used in pairs and cross-connected, for it must be remembered that they are essentially rectifiers, and separate units must be provided for the positive and negative half-cycles respectively.

Motor Control.

Electric control-gear engineers know that the only essential difference between a relay and a contactor is in size ; *e.g.*, while the contacts of a relay may pass a few milliamperes, a contactor is called upon to handle from one to several thousands of amperes. There is hence no need to explain why valves can function as contactors and can be used to build up automatic control schemes that can carry out even more elaborate functions than electro-magnetic contactors.

The basic principle of typical electronic motor-control schemes is the use of a D.C. motor upon an A.C. supply ; the valves fulfilling the dual function of rectifying and controlling the current. Moreover, the control not only includes switching on and off, but may also include speed variation by both armature and field regulation, and that with negligible power loss, as in the circuit shown in Fig. 8. When a triode is used as an on-and-off contactor, *i.e.*, for plain switching duty, the grid corresponds to the operating coil of the contactor. When it is used for voltage or current variation, the "firing" point, *i.e.*, the point at which it starts conducting in each half-cycle, is varied by adjusting either the voltage or the phase-angle of the control wave applied to the grid. In this way,

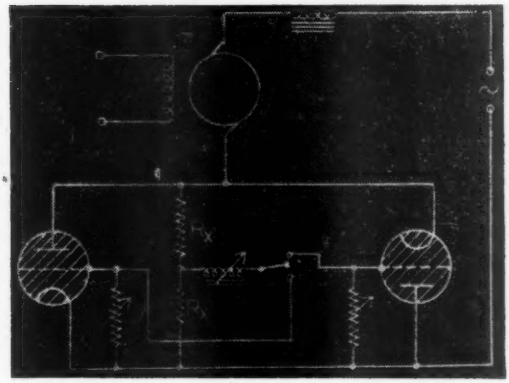

FIG. 8. Motor Control Circuit (*courtesy of Beama Journal*).

the area of the current wave, and therefore its R.M.S. value, is altered.

Voltage Regulators.

The automatic regulation of generator voltage in power stations is effected by means of either occasionally moving or continuously vibrating contacts. In both cases absolute reliability is required, implying careful maintenance. Both methods lend themselves to electronic operation, but perhaps that which involves continuous movement has most to gain when this is replaced by the grid control of a valve. In a successful circuit, shown in Fig. 9, developed by the

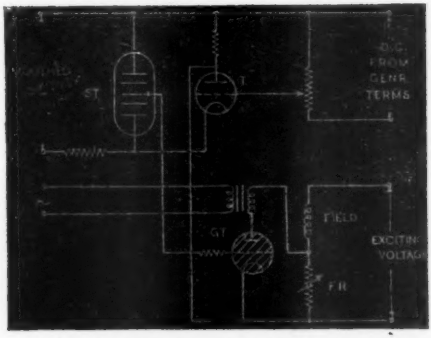

FIG. 9. Voltage Regulator Circuit (*courtesy of Beama Journal*).

firm with which the author is associated, a gas triode is connected across the field rheostat, and is caused to "go out" 50 times per second by the injection of an alternating pulse in the anode circuit. The grid circuit is connected across a bridge formed by the two parts of a Stabilovolt on the one side, and a resistor and the plate circuit of a triode on the other. A voltage proportional to that given by the generator is applied to the grid of the latter, so that the effect of voltage fluctuations is to alter the resistance of the triode and thus vary the proportion of the cycle during which the gas triode conducts. As the conducting period forms a short-circuit across the field rheostat, effective regulation is achieved.

Synchroscope.

The examples so far given have purposely been chosen to illustrate power current applications of electronics ; but there are numerous auxiliaries in power engineering which are of an "instrumental" nature and which there is hardly time to describe now. One such scheme may, however, be included, partly because it replaces a small motor mechanism, and partly because it illustrates the use of the cathode ray oscilloscope in power supply or industrial situations. This is shown in Fig. 10.

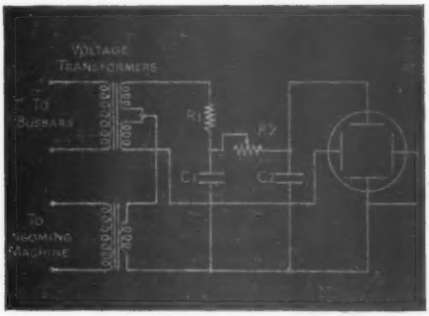

FIG. 10. Synchroniser Circuit (*courtesy of Beama Journal*).

Indication of synchronism between the busbars and an incoming machine is usually carried out by a small split-phase induction motor, with its rotor and stator supplied from the 110 V. secondary windings of the respective metering voltage transformers. A certain electronic equivalent consists of a scheme for enabling a cathode oscilloscope to produce a rotating diametral line that moves just as in the case of the motor-driven indicator. In this case the voltage transformer leading from the busbars has duplicate secondary windings, each

giving the full secondary voltage. Then the secondaries are connected in series with each other, first with the "busbar" connections in one direction and, secondly, by means of the duplicate winding in reverse. One of the resultant circuits is connected to the "horizontal" deflectors, and the other is retarded by 90 degrees and taken to the "vertical deflectors." The vector diagram indicates that the voltages as applied to the deflectors are in phase with each other and thus produce a line and not an ellipse; and that this line rotates in a direction showing whether the incoming machine is fast or slow, the position of the line also showing when exact synchronism is reached.

Cathode Ray Tubes.

No instrument has made such rapid strides as the Cathode Ray Oscillograph, or found so many applications in all branches of industry and science. Originally designed about 1897 in connection with a very advanced research in pure physics, it has been developed into an extremely robust, versatile and efficient measuring device for any kind of industrial situation, as well as in hospitals and modern research laboratories of all kinds. At the same time its cost and the skill required in its operation have been reduced to remarkably small proportions.

One of its capabilities may be mentioned by way of illustration, namely its power of tracing very distinct curves recording the progress of an experiment, at "writing" speeds of up to 500 miles *per second*; and this by means of a complete equipment costing less than £100.

An example from another field is the great service rendered by the cathode-ray tube to television, where the high modern standard of reproduction is due to the adoption of this principle for both transmitting camera and receiving screen.

Electron Microscope.

Perhaps the electronic device that is destined to affect the lives of all of us to the greatest extent in the next few years is the electron microscope. A development of the cathode ray tube in which the usual focussing elements have been made much more precise and powerful, its conversion to a standard laboratory and industrial instrument within the past 3 years has suddenly increased the highest magnification hitherto practicable from × 1,500 to × 150,000 with a prospect of further great improvements to follow. As an immediate consequence, every branch of science has had its frontiers extended to a sensational degree, and great benefits are already the natural outcome. The agencies causing obscure diseases are being identified, the mechanism of chemical reactions is being revealed,

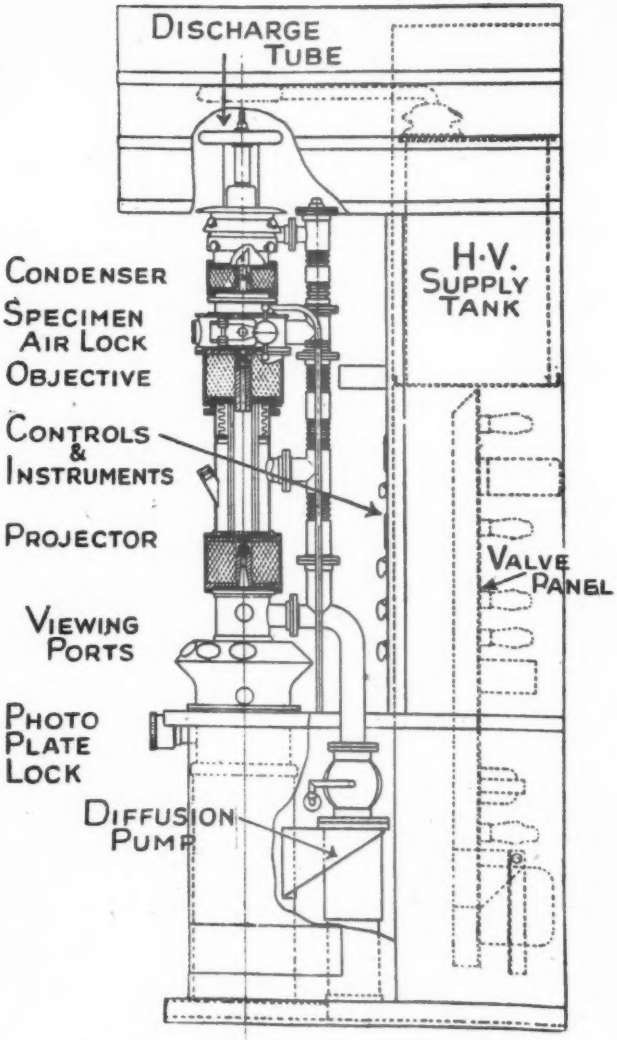

FIG. 11. R.C.A. Electron Microscope.

the form and behaviour of dusts and smokes are being correlated, the action of drugs on the human body, of fertilisers on the soil, and of catalysts are being witnessed, and many particles such as molecules, so small that their inspection was never considered possible even by the most sanguine, are being rendered visible. Striking examples (shown to the meeting in the form of lantern slides) are the viruses of tobacco mosaic disease and of influenza (× 55,000 and × 100,000), smoke particles from burning zinc and magnesium ribbon, polyvinyl chloride (P.V.C.), synthetic "rubber" (× 100,000), showing mottling due to molecules, and antibodies attacking a bacterium from the human intestines (× 70,000).

The R.C.A. electron microscope is shown in section in Fig. 11, the condenser lens, objective, and eyepiece (projector) lens being seen as iron cored solenoids, projecting the enlarged image upon the fluorescent screen at the bottom. In Fig. 12 are shown four typical records.

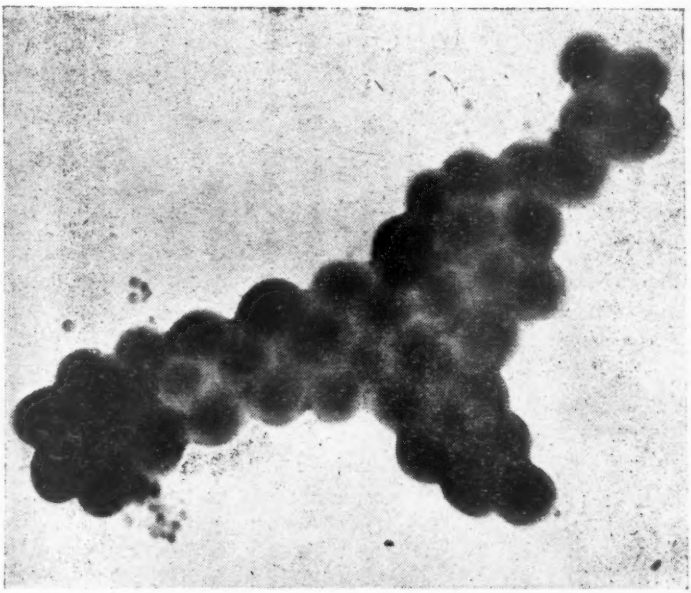

FIG. 12a. Staphylococcus Aureus, × 22,000. This is the microbe which causes boils.

The photoelectric cell, shown as C.7 in Fig. 1, performs its most important office by taking the place of the human eye in an electrical control installation. As such it is able to bring about such operations as the closing of a relay when a moving part has reached a predetermined position, or to count articles as they pass, to cause a mechanism to function when smoke is present in a sufficient quantity, to open a door when a person approaches it, or to govern the closing of a swing bridge.

Probably the last is that most interesting to production engineers, and a brief description is therefore given of the application of photo-cells to the Kincardine Bridge over the Forth near Edinburgh. As the swing span has a total length of 364 ft., it would not be

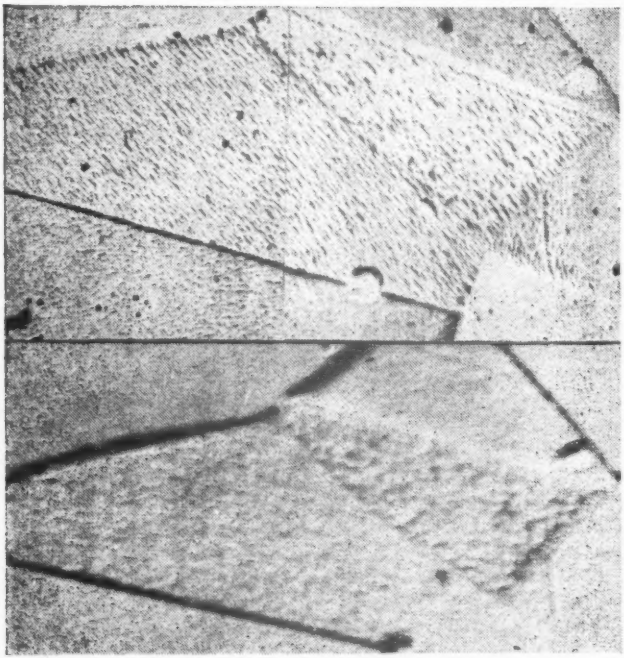

FIG. 12b. Comparison of electron and light micrographs of stainless steel (18-8), × 4,800. The magnification in the case of the light micrograph (*bottom*) is far in excess of the detail which can be obtained, whereas the details of the crystals in the electron micrograph (*top*) are very sharp and informative.

possible for the operator in the central control room to see whether the two roadways were in exact register upon closing, and accordingly a lamp box containing three lamps in a horizontal row, and a fourth above these, is fixed to each abutment just below the roadway. At the same level on one end of the swinging span is a somewhat

FIG. 12c. Bacilli of Aerobacterium Cloacae. × 54,000, from the human intestine. Note the details of the body structure, including the capsule and long flagella.

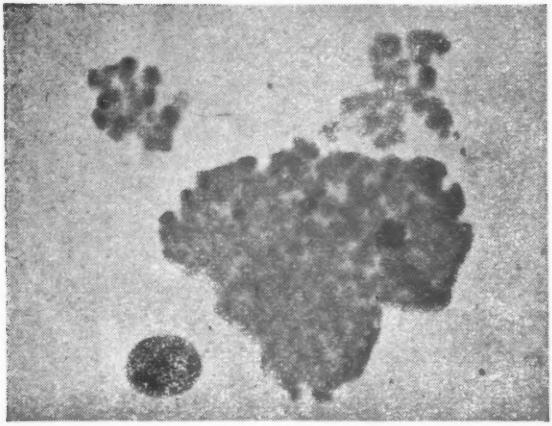

FIG. 12d. The microbe shown in (a), to the same scale, after treatment with penicillin.

similar box, seen in Fig. 13, containing three photo-cells, one higher than the other two.

When the span has nearly reached its final position, the first lamp energises the first cell, which rings a bell and operates a signal lamp on the control desk ; and this action is repeated by the other two lamps in the row as closing proceeds. Immediately afterwards, the fourth lamp is able to shine through a narrow slit upon the middle photo-cell, registering exact coincidence of the two roadways ; while the third cell would be energised by the first lamp if the span overshot the mark. The operation of the photo-cells cuts off the span motors ; but as the exact coming to rest of the moving mass depends upon weather conditions, and it is inadvisable to use the brakes more than necessary, "inching" push-buttons are fitted which enable the operator to bring about exact registration with the aid of the indication afforded by the photoelectric gear.

Mechanical Analogies.

The author pointed out at a recent London discussion* that mechanical and hydraulic engineers use their valves much more than we electrical men do ours ; and that as the diode and triode are able to provide the exact electronic equivalents of the non-return,

* See discussion to Bowdler's paper, "Measurements on Impulse Voltage with a Ballistic Galvanometer," J.I.E.E., May, 1942, Vol. 29, p. 237.

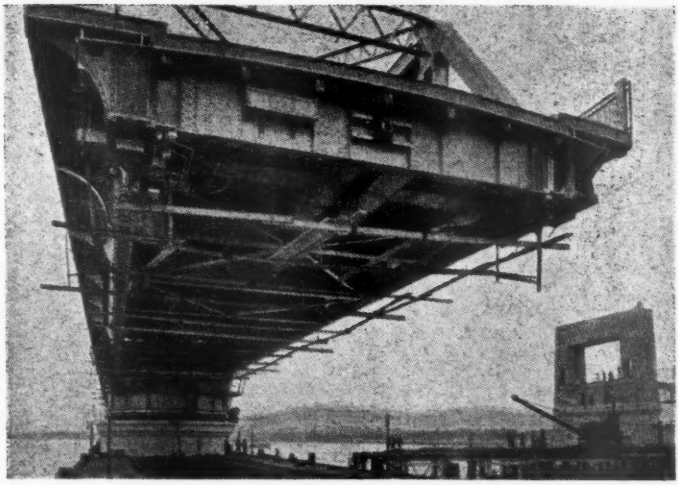

FIG. 13. Kincardine Bridge (*courtesy of G.E.C., Ltd.*).

throttle and safety valves, they afford an opportunity for building up new devices on the analogy of mechanical apparatus.

As a simple example, suppose it were desired to measure the crest voltage of an impulse by the use of valves. Then a mechanical method for doing this in the case of, say, the Severn bore would be to erect a stand-pipe with a non-return valve at its lower end, which would be fixed in the river just below normal water-level. After the surge had passed, a pressure-gauge or spring balance would measure the quantity of water that had been entrapped, and the height would be proportional to this quantity. The neat electrical method described in the paper which was then discussed forms the electronic equivalent, a condenser being charged through a diode, and the charge measured by a ballistic galvanometer.

Conclusion.

The above are only a few of the many instances that could be quoted to illustrate the rapid advances being made by electronic methods in the realm of heavy as well as light current engineering. Sufficient examples have, however, been described to indicate the trend of recent developments. The contrast between the present high rate of advance and the slow progress of only a decade or two ago points to the great advantage to be gained by adopting a broad

outlook in research and by coordination between workers in different fields. It is the author's hope that this brief survey may do something towards furthering such co-operation, and also towards providing an indication of important possibilities in the immediate future.

REPORT OF DISCUSSION ON "ELECTRONICS IN ENGINEERING"

Given at Leicester Section, 11th October, 1945.

CHAIRMAN: I am sorry that we are a few minutes late in starting. First of all, let me say that this is a joint lecture meeting of the Leicester Section of the Institution of Production Engineers and the Leicester Association of Engineers. Mr. Leedham is going to deputise for Mr. Hill.

The subject of the lecture to-night is "Electronics in Industry," and the lecturer is Dr. W. Wilson, who is in charge of the Research Department of the General Electric Company at Witton, Birmingham.

When we put this subject up to Dr. Wilson, we told him that we wanted a lecture that was applicable to mechanical engineering, as distinct from electrical or radio engineering. Most of us have read lectures and articles in the various papers on different aspects of electronics, but whether they have appealed to you as they have appealed to me, they have all been very technical. We felt we wanted something more understandable from the mechanical point of view, *i.e.*, the application of electronics to mechanical engineering. Dr. Wilson has lectured before, and I am hoping he has been able to introduce certain elements into his lecture to-night which will give us an idea of the practical application of electronics to engineers. I now have much pleasure in introducing Dr. Wilson.

(DR. WILSON then delivered his lecture.)

CHAIRMAN: I am afraid that Dr. Wilson has exceeded the time allotted to him, and therefore we shall have to make the discussion as brief as possible. I will call upon Mr. Law to open.

MR. LAW: First of all, I should like to express my personal appreciation of Dr. Wilson's very interesting lecture to-night. It seems as though electronics is going to revolutionize many problems in the shop, examining, testing, etc., heat treatment, and finally is going to help our bodily ills. Seriously now, I have seen the application of dielectric heating, and while it is certainly rather more simple than the accepted methods, I should like to know what is going to happen when case-hardening. Are we going to get hard and soft spots? Another point, there might be a change between the case-

hardened surface and the parent metal—is there any guarantee that the change is going to be gradual ? Another point with regard to high frequency heating—do we have to assume that it can only be applied to non-conductors ? And what about bonding non-metals to metals, etc. ?

In reply to Mr. Law :—

It is certainly true that Electronics can revolutionise a number of shop problems. In practically every case of high frequency heating the effect of the electronic principle is to effect the application of the heat so that it takes place—

(*a*) at exactly the right place ;
(*b*) to exactly the desired amount ;
(*c*) to exactly the correct length of time.

In addition, there is an assurance of cleanliness and uniformity that renders the quality of the work still more dependable. As heat control is essentially automatic, the results can be reproduced to a high degree of consistency. All these advantages will be seen to rule out the possibility of hard and soft spots ; and I think it will readily be seen that irregular results are rendered almost impossible. Further, the application of the heat can be so regulated that the depth of the hardened skin can be fixed at any desired value. There is no more risk of this skin becoming detached than with any other form of heat treatment ; in fact I have never heard of such an occurrence taking place with high frequency heating.

I have described in the paper the different methods whereby heating is developed in conductors and non-conductors. In the former, the conductor is caused to function as the short-circuited secondary of a transformer, and is heated by large eddy-currents, while in the latter, the insulator to be heated is treated as the dielectric in a condenser, and the frequency increasing to such a point (*e.g.*, 10 to 20 megacycles per second) that the losses through capacity currents produce rapid heating. When there are metal inserts present in insulation they usually form quite a small proportion of the whole volume, which is treated as though it were insulation and heated by capacity current. In any case, the conductors are not affected by the high voltage.

Second question : In electronics we have a more sensitive means of controlling mechanical movements. In order to give effect to this control we must have motors, etc., which have their own respective inertia, but I believe the time-response of a standard motor is one-tenth second and unless that can be improved there are serious obstacles in further development of electronic control. I wonder whether you can say what can be expected in the near future ? Further, you did mention that electronics can effect improvement in "servo" mechanisms. There will be some displacement ; can

you give us the relationship between the speed of displacement and the error after that displacement has been put into effect ?

In reply to the second question, it is quite correct to say that electronics provides a more sensitive control for electric motors. The advantages in this respect are absence of time-lag and therefore a more exact timing than with other methods, the avoidance of auxiliary relay contacts and moving parts generally, and the carrying out of sensitive control without the use of current-carrying resistors. The control means has therefore better characteristics than the motors themselves as regards speed of response, and it is now the performance of the motor that imposes the limit. Fortunately, there are methods of decreasing the delay in the motor. The latter consists mainly of two parts—(*a*) magnetic time lag, and (*b*) mechanical inertia. The first can be countered by reducing the amount of iron in the magnetic circuit, and this is done partly by the physical design and partly by the substitution of soft steel for cast iron. Mechanical inertia is reduced by lightening the moving parts, which usually consist of the armature in the case of a motor; while in addition, low inertia armatures are designed to have a small diameter and a relatively great length.

I am afraid it is not possible to quote figures for the improved results of Servo mechanisms as these were largely developed for the Services during the war, and the figures relating to such apparatus are still confidential. Unfortunately, it is not possible to express such characteristics in simple units.

I will just say that the principle of electronic motor control is that you operate a direct current motor from alternating current mains. The valves act as rectifiers and controllers. I did tell you how the control was effected. The great advantage of electronic control is that there is no loss. There is no need to use resistors. The voltage and current are cut down by reducing the length of the cycle during which the current is flowing : the application of the time impulse to the grid. It is efficient, sensitive and direct. You can have your reversal and rise of voltage applied at exactly the right rate and time. Furthermore, you avoid the use of contacts with all that that implies, so that electronic control is more reliable. On the other hand, you may have fairly large valves as soon as the motors get large, and you find to-day that it is only the small sizes that are being electronically controlled. When large valves are developed, all that will be altered. Of course, large valves are in use—for instance, the 500 kW valves employed by the B.B.C. We have not got a very big range of gas-filled triodes yet, but motors up to 10 or 20 horse-power and larger will be electronically controlled as an ordinary measure. The motors with which I have been concerned use the small steel-cased rectifier, which is a type of valve in which you can get a very large amount of power, but I will repeat that the characteristics of the control depend

upon what the motor will stand, and it will apply to a motor the maximum power that the motor will stand ; and as it is smooth instead of in steps, and as the rate at which it can be applied can be controlled, you can get the maximum duty out of the motor without over-heating. That will be one of the great benefits resulting from electronic control.

MR. HILL : I should like to propose a very hearty vote of thanks to Dr. Wilson for his extremely interesting lecture. It is a special privilege to have been asked to propose this vote of thanks, Dr. Wilson is really a born teacher as well as a born scientist. He started with first principles and has taken us right through ; anyone could understand, and his material was particularly interesting. In addition to all this, he has quite a vein of humour. He mentioned the possibility of crustless bread—I wonder what he would say if he had been baking a loaf by electronic heating, and when he opened it, found the crust inside ! (*Laughter.*)

One point—regarding controls for motors, are you able to use them for controlling speed ? (LECTURER : Yes—direction of rotation and speed ; and all without resistors.)

Well, we have had a very comprehensive range of things put before us, and I do wish, on behalf of the two Societies, to propose a very hearty vote of thanks to Dr. Wilson. (*Applause.*)

Research Department: Production Engineering Abstracts

(Prepared by the Research Department.)

NOTE.—*The Addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough. Readers applying for information regarding any abstract should give full particulars printed at the head of that abstract including the name and date of the periodical.*

HEAT TREATMENT.

Heat Treatment of Steel. (*Industrial Gas Times, January*, 1946, *Vol. IX, No.* 100, *p.* 93, 3 *figs.*)

"Interrupted quenching" consists of quenching into a medium maintained at a temperature considerably higher than the 75° to 150°F. range of the usual oil, water, brine or air quench, and the basic principles involved are thoroughly discussed. To overcome difficulties with normal water and oil quenches, three methods of interrupted quenching are being used: (1) austempering, which is limited to steel parts of small section and of certain analyses; (2) isothermal quench, used for steel parts of relatively heavy section and for higher physical properties than is possible with austempering; and (3) martempering for hardening heavier sections than can be hardened by any other known method of interrupted quenching, and especially valuable for steels which are normally known as "shallow hardening."

Molten salt has been the most commonly selected medium, but "controlled gas atmosphere quenching," which consists of rapid cooling in a prepared gaseous atmosphere vigorously circulated in large volume, may in the future be used for interrupted quenching of thin and medium sections. The design and operation of hardening and salt quench furnaces are also dealt with.

How Heat-treatment Affects High-strength Irons, by Dr. C. R. Austin. (*The Machinist, 2nd February*, 1946, *Vol.* 89, *No.* 43, *p.* 2326, 10 *figs.*)

Where a casting is complex in form, involving abrupt section changes, internal stress may result from varying cooling rates, and annealing is more effective in removing casting stresses than ageing or weathering. Recommended annealing temperatures are given. Two types of annealing are used to improve machinability, low temperature and high temperature. High-strength Meehanites are comparable to carbon steel in their response to hardening by quenching in water or oil from above the critical change temperature. Interrupted quenching suppresses pearlite transformation but avoids the formation of martensite, which results from the usual oil or water quench treatment, but is effective only for castings of relatively small size, where it can be employed to increase markedly the tensile strength and hardness without loss of toughness. Martempering is particularly useful where an intricate casting has to be hardened, and where cracking may be found to occur when using the conventional oil or water quench.

Dimensional Stabilization by Deepfreeze. (*Machinery, 14th February*, 1946, *Vol.* 68, *No.* 1740, *p.* 215.)

The results of deepfreeze treatment of ten bearings are given, with recommendations by the U.S. Bureau of Standards for finding the number of cycles necessary for stabilizing a component.

COOLANT, LUBRICANT.

Cutting Oils, by Arthur E. Lawson. (*Engineering Materials, February*, 1946, *Vol. IV, No.* 10, *p.* 280, 2 *figs.*)

Necessary qualities of coolants are: to cool both work and and tools, provide adequate lubrication between chip and tool, wash away ships, provide a wetted surface on the work, reduce power consumption, and preserve against corrosion and gumming of work and machine. A water emulsion is cheap and should always be used where the work is within the lubricating capacity of the film provided. There are many cases where dry cutting can be accomplished. The best opaque emulsions have a coarse molecular structure in the emulsified state which enables the fatty portions to deposit on the tools and provide a good lubricating film, the water content keeping the whole combination temperature-controlled. Clear types are most useful when the engagement of the tool with the work must be observed and for grinding operations.

Special purpose soluble oils have been developed for aluminium and cast iron. Effect of metals, hard water and careless mixing must be appreciated and the correct precautions taken. The commonest form of straight cutting oil is the sulphurised type. The fat imparts a rich film permitting an easier glide of the chip over the tool and more consistent tearing or rupture from the main stock. Generally speaking, two straight cutting oils can cover the essential requirements of the average factory and a guide to selection is given.

EMPLOYEES, ETC.

Personnel Work and Employers' Associations. (1) The Objective to Follow, by F. E. Chappell; **(2) The Scope of a Central Personnel Department,** by Robert Watson. (*Industrial Welfare, January-February*, 1946, *Vol. XXVIII, No.* 304, *p.* 4.)

(1) The Board of Trade view is given. It is suggested that a great deal can be done by Trade Associations to help the smaller firm. The Board of Trade hope to put an advisory service at the disposal of the smaller company who cannot afford the high fee of a consultant. The Government has decided to set up a committee to define the initial constitution of a British Institute of Management, and to launch this Institute into the management field. It is hoped to co-ordinate those acknowledged existing associations which may at present be somewhat overlapping in their functions, and to link them up into one British Institute of Management.

(2) Established personnel management practice is very rare at Employers' Association level, and except for advanced employers it is very poorly developed in industry as a whole. The aim and purpose of personnel management in the service of a private employer must be to apply humanitarian principles in order to help the business operate at a profit. An account of such work in actual practice in a Trade Association is given. A central personnel department can act as a consultative and advisory service to the trade as a whole, accumulate and disseminate information on personnel practices of members, assist in improving the techniques of joint consultation, conduct wage and salary surveys to assist the maintenance of equitable salary and wage structures, provide the services of a central medical officer, industrial psychologist, and others, maintain closer contact with central and regional officers of various Government Departments and maintain contacts with the various national bodies working in the management field.

FOUNDRY, CASTING.

Weight Estimation for Die Casting, by H. K. and L. C. Barton. (*Machinery, 31st January*, 1946, *Vol.* 68, *No.* 1738, *p.* 159, 4 *figs.*)

Part 2. The necessary calculators for further geometrical shapes are described.

Steel Spar Casting. (*Aircraft Production, February*, 1946, *Vol. VIII, No.* 88. *p.* 85, 28 *figs.*)

The design and manufacture of a highly stressed member is described in detail. Inspection procedure and information on rejection are also given.

GEARING.

Basic Relationships of Bevel Gears, by Ernest Wildhaber. (*The Machinist*, 19*th January*, 1946, *Vol.* 89, *No.* 41, *p.* 2245, 7 *figs.*)

Part 1. Basic bevel gear formulae are re-derived, and profile sliding is treated in a new way.

MACHINE ELEMENTS.

Ball, Roller and Needle Bearing Application, by G. W. McArd. (*Mechanical World*, 1*st*, 8*th February*, 1946, *Vol.* 119, *Nos.* 3083, 3084, *pp.* 117, 150, 35 *figs.*)

Current general practice is first comprehensively reviewed. Methods of calculating bearing loads, including gear and other drive applications, are then given, and the article concludes with general manufacturing and installation precautions.

MACHINERY, MACHINE TOOLS.

New Machine Tools and the Future, by Wm. G. Marsden. (*Machinery*, 24*th January*, 1946, *Vol.* 68, *No.* 1737, *p.* 122.)

Manufacturers' and users' ideas, desirable standard features, simple fast-operating machines of up-to-date design, chipless machining, the hiring or renting of machines instead of outright sale, plant replacement, and sales promotion for the machine tool are discussed critically.

Wide Speed Ranges with Electric Servo-mechamisms on Machine Tools. (*Machinery*, 14*th February*, 1946, *Vol.* 68, *No.* 1740, *p.* 217, 1 *fig.*)

With the adaptations of servo-mechanisms, electrical drives on machine tools can cover wide feed ranges without any mechanical linkage between the table and the feed screw. For a boring mill, to vary the feed per revolution of the table, a speed-changing mechanism must be introduced between the table and its servo-unit. However, this device is much simpler and less expensive than the speed-changing mechanism usually built into the gear box on the rail of a conventional boring mill.

Thread-grinding Practice with Single-edge and Multi-edge Wheels. (*Machinery*, 14*th February*, 1946, *Vol.* 68, *No.* 1740, *p.* 211, 3 *figs.*)

Thread grinding is now found profitable in soft materials and in cases where extreme accuracy is not required, as the cost compares favourably with other methods. The wheels used for thread-grinding and their selection are discussed. The technique of thread grinding is detailed for single- and multi-ribbed wheels and recommendations are given for wheel and work speeds, truing by diamonds, and dressing by crushing.

Some Unusual Grinding Set-ups. (*Machinery*, 7th *February*, 1946, *Vol.* 68, *No.* 1739, *p.* 177, 8 *figs.*)

Arrangements to solve difficult grinding problems, or to secure faster or more accurate production, are described.

CHIPLESS MACHINING.

Rolling Precision Threads. (*The Machinist*, 19*th January*, 1946, *Vol.* 89, *No.* 41, *p.* 2235, 5 *figs.*)

The process of rolling threads is not new, but during the war it was adapted to the rapid production of studs in urgent demand for the aircraft industry. A wider adoption of the process is anticipated, and this article discusses its practical aspects, with particular reference to rolling with cylindrical rolls.

Developments in Rubber Press Die Work, by F. L. Joyce. (*Machinery*, 7*th February*, 1946, *Vol.* 68, *No.* 1739, *p.* 181, 14 *figs.*)

Free-rubber and trapped rubber applications are compared with the aid of examples, attention being drawn to the different behaviour of soft and hard rubber. The existence of free-rubber conditions in a supposed trapped-rubber set-up is demonstrated, and the true trapped-rubber conditions are illustrated. It is emphasized that the usefulness of a hard-rubber medium is restricted, and its limitations are very sharply defined. Soft rubber under compression will perform these operations just as effectively, and at the same time give greater scope by forming smaller flanges, adapting itself to quite intricate formations, and making possible considerably deeper draws. The saving on tooling up for hard rubber as compared with that for soft rubber is a false economy, and may eventually prove detrimental in practice. The characteristics of various media for the tools, including hardwood, fabricated products, castings, steel and compound wood and metal are reviewed. The article is completed by a critical examination of the tooling for an actual product.

Annealed Aluminium Alloys Respond to Hot Forming, by George Sachs, George Espey and W. F. Brown. (*The Machinist*, 16*th February*, 1946, *Vol.* 89, *No.* 45, *p.* 2385, 13 *figs.*)

Part 1. The behaviour of aluminium alloys when stretched or formed at elevated temperatures presents varying commercial possibilities. In mechanical circular bulging, involving biaxial stresses, some alloys show increased formability with increased temperature, particularly in the annealed condition. The importance of proper lubrication at elevated temperatures is clearly indicated.

To survey the effect of elevated temperatures on mechanical bulging, 20 different conditions of six alloys were investigated in plant tests. In general it appears that for annealed alloys, some practical advantage may be gained by hot die-forming under favourable geometrical conditions. It is apparent that forming limits for various stress states obtained in elevated temperatures cannot be predicted successfully. Thus the results obtained in hot hydraulic bulging and in the elevated temperature tension tests fail to predict quantitively the effects of temperature on the forming limits in die bulging. The most important effect of temperature is its influence on the lubricant and the friction co-efficient. For each testing temperature, condition of geometry and alloy there is a lubricant particularly suited to furnish maximum formability. Commercial soaps provide most dependable high-temperature lubrication.

Magnesium Can Be Deep Drawn. (*The Machinist*, 9*th February*, 1946, *Vol.* 89, *No.* 43, *p.* 2339, 7 *figs.*)

Under proper temperature conditions this metal excels others in withstanding plastic deformation, and examples are described, the most remarkable being a propeller dome fabricated in a hot-pressing operation.

Metal Spinning Processes, by A. J. T. Eyles. (*Mechanical World*, 15*th February*, 1946, *Vol.* 119, *No.* 3085, *p.* 171, 4 *figs.*)

Metal spinning is finding new applications and also increasing uses in connection with pressing. The spinning machine and tools are described, and particular attention is paid to the spinning of aluminium.

MANUFACTURING METHODS.

Time and Motion Study—A Consideration of Fundamental Principles, by John W. Hendry. (*Machine Shop Magazine, January*, 1946, *Vol.* 7, *No.* 1, *p.* 36, 2 *figs.*)

Part I. This is of an introductory nature setting forth some of the underlying principles of time study, and discusses the importance of wages, advantages of time study, the "norm," and the elimination of hidden idle time.

The Marshall Cabin-blower. (*Machinery*, 17, 24*th January*, 1946, *Vol.* 68, *Nos.* 1736, 1737, *pp.* 69, 105, 18 *figs.*)

The location, machining and inspection of accurate bores in the rotor case are described. The rotor blades machined from light-alloy castings require the manufacture of accurate surfaces by finish-milling with a single-blade cutter ground to the correct form. After the form-milling operation, the form is checked by comparing the profile of the rotor blade with a master profile and dial gauges. Before being assembled in their casings, the rotors are checked for blade clearance, and the blades are scraped where necessary.

Rolls-Royce Griffon 65, by J. A. Oates. (*Aircraft Production, February*, 1946, *Vol. VIII, No.* 88, *p.* 59, 35 *figs.*)

Part I. Details of design; machining the forked connecting-rod; crankshaft production.

MATERIALS.

A Novel Shock Absorbing Material, by H. Sanders. (*Engineering Materials, February*, 1946, *Vol. IV, No.* 10, *p.* 290.)

A new material has been developed in the U.S.A. for absorbing heavy impact shock and transmitted high-frequency vibration. It is composed of plies of tightly twisted, closely woven light weight cotton duck. Each ply is thoroughly impregnated with a special rubber compound, and the plies are built up to the desired thickness, then united by a vulcanising process. It has been used as a mounting for forging hammers, grinders, and compressors apart from numerous general engineering applications.

MEASUREMENT, INSPECTION.

Electronic Measurement, Analysis and Inspection. (*Machinery*, 24*th January*, 1946, *Vol.* 68, *No.* 1737, *p.* 113, 9 *figs.*)

Applications of electronic devices in the mechanical field include X-ray machines used to detect flaws in heavy castings, the measurement of the vibrations of a thread-grinder, balancing machines, surface finish measurement, micrometers for easily deformable workpieces, strain gauges, pyrometers and microscopes.

PLASTICS, POWDER METALLURGY.

Products Formed with Laminated Plastics. (*The Machinist*, 16*th February*, 1946, *Vol.* 89, *No.* 45, *p.* 2377, 6 *figs.*)

The Guerin technique involved is described. Phenolic synthetic resins are thermo-hardening, but the material does, to some extent, become softer under the application of heat. Laminated sheet is heated on a hot plate; in a hot air oven; in a hot oil or glycerine bath; or by infra-red radiation. Hardwood or

Bakelite laminated tools stand up well, are light to handle, and are readily altered or replaced. Details are given. Certain precautions which must be taken are indicated.

Plastics Increase Power-Metal Flow, by Harry L. Strauss. (*The Machinist, 26th January*, 1946, *Vol.* 89, *No.* 42, *p.* 2275, 1 *fig.*)

Limitations upon part shape are reduced by using a plastic as a liquid vehicle, and then burning it off before final compacting.

The Application of Powder Metallurgy to Engineering Products, by J. A. Judd. (*Engineering Materials, February*, 1946, *Vol. IV, No.* 10, *p.* 275.)

Powder metallurgy process can be considered from two angles: (1) the fabrication of products which could not be made by any other method, and (2) the production of articles which require a large amount of machining when made by normal methods. Under (1) are porous bronze bushes, cemented carbide tools, contact materials, porous filters, and permanent magnets. In the second class of materials little progress has been made in this country compared with the U.S.A., and the author discusses this section in some detail. The properties and production of sintered iron are described and information is given on strength properties, cost, tolerances, size limitations and general design considerations. Extended use is mainly dependent on the development in this country of suitable plant, mainly presses and sintering furnaces, and the acquisition of cheaper powders.

RESEARCH.

The Control of Industrial Research. (*The Management Review, December*, 1945, *Vol. XXXIV, No.* 12, *p.* 471.)

This discussion is restricted to the planning and control methods used in various fields of technical research. The methods apply both to fundamental or basic research and to development work, or research on products and processes. Organisations of the research department, the research committee, preparation of cost estimates, the research budget, authorisation procedure and cost accounting are dealt with.

SHOP MANAGEMENT.

Train Foremen in Work Simplification. (*The Machinist, 2nd February*, 1946, *Vol.* 89, *No.* 43, *p.* 2307.)

Principles of work simplification, taught in twelve sessions, make for better supervision and lead directly to valuable suggestions for improvements. The scope of each session is given in some detail, and the general nature of the course, which has produced successful results with about 500 foremen, is clearly indicated.

SMALL TOOLS.

Simplified Tools Designed for Broaching Spline Forms, by H. H. Gotberg. (*The Machinist, 2nd February*, 1946, *Vol.* 89, *No.* 43, *p.* 2315, 8 *figs.*)

Involute splines have gained favour as requirements call for stronger and more accurate connections. The design of broaches and methods of spline production are outlined for both straight and spiral splines.

SURFACE, SURFACE TREATMENT.

Shot Peening Metallic Surfaces. (*Machinery Lloyd*, 19th *January*, 1946, *Vol. XVIII*, *No.* 2, *p.* 71, 9 *figs.*)

The principle of peening to increase fatigue resistance is described and actual test results, including some taken on Almen specimen gauges, are given. Examples of multi-rotary-table and of conveyor pattern devices for shot peening are illustrated.

Blue-Finishing Steel, by L. Sanderson. (*Engineering Materials*, *February*, 1946, *Vol. IV*, *No.* 10, *p.* 300.)

The parts most often treated in this way include tools, dies, stamping, gauges, jigs, gun barrels, and those objects whose decorative appearance requires improvement. The process is described in detail.

The Corrosion of Metals. (*Sheet Metal Industries*, *February*. 1946, *Vol.* 23 *No.* 226, *p.* 309, 15 *figs.*)

Part 1. Factors affecting corrosion, the ill-effects of corrosion, the examination of corrosion failures, the nature and the mechanism of corrosion and the electro-chemical phenomena concerned are fully discussed.

The Chemistry and Mechanism of Steel Pickling, by Brian N. Reavell. (*Sheet Metal Industries*, *February*, 1946, *Vol.* 23, *No.* 226, *p.* 323.)

The subject is generally surveyed, and the author deals with the chemical reactions, the mechanism of pickling, pickling plant, acid storage and handling, acid heating and acid neutralisation, and acid recovery.

Three Examples of Modern Practice in the Recovery of Waste Pickling Liquors, by Paul de Lattre. (*Sheet Metal Industries*, *February*, 1946, *Vol.* 23, *No.* 226, *p.* 282, 6 *figs.*)

Examples of the author's process for pickling welded seamless and high-precision tubes are described. A continuous regeneration plant, eliminating entirely the need for settling and deposit tanks, has been installed in one case.

The Decoration of Blackplate and Tinplate, by T. A. Miller. (*Sheet Metal Industries*, *February*, 1946, *Vol.* 23, *No.* 226, *p.* 291.)

Recent developments and future possibilities.

TECHNICAL INFORMATION.

Establishing and Organising the Technical Library, by Constance B. McKay. (*The Commonwealth Engineer*, 1*st December*, 1945, *Vol.* 33, *p.* 155, 8 *figs.*)

The policy of the librarian must be to insist on orderly classification and cataloguing. Though an improvised system of classification may appear suitable to the needs of the small library, as it grows innumerable difficulties present themselves and it is best to start with standard methods such as the Dewey Decimal System and the Universal Decimal Classification. Comments on the scope of these two systems are made. A card catalogue is the only one recommended for modern library practice because of the necessity for maintaining a flexible alphabetical arrangement. In special library work there is much to be said in favour of separate author and subject indices. A very important section of the technical library collection, and one which presents perhaps the greatest difficulties in arrangement, is the technical data file. This includes pamphlets, trade catalogues, typescript reports and extracts, reprints and photographic reproductions. Suggestions for recording, circulating and filing periodicals are made. Valuable published indices to periodicals such as the Industrial Arts Index and Engineering Index are essential. The Microfilm permits the recording of publications which could not otherwise be handled.

TRANSPORT, TRANSPORT EQUIPMENT.

Heavy Handling Aided by Motion Study, by M. E. Mundel. (*Machine Shop Magazine, January*, 1946, *Vol.* 7, *No.* 1, *p.* 48, 4 *figs.*)

Forty-seven per cent. less time and travel resulted from the application of a simple motion-study analysis to a material-handling job.

Make Conveyors Match the Job. (*The Machinist*, 26*th January*, 1946, *Vol.* 89, *No.* 42, *p.* 2267, 4 *figs.*)

The principal feature of this article is a list of twenty questions covering the points to be settled when arranging a conveyor system.

WELDING, BRAZING.

Bailey Bridge Production, by C. A. Kershaw. (*Welding, February*, 1946 *Vol. XIV, No.* 2, *p.* 62, 7 *figs.*)

Part 2. Welding methods and control procedures.

The Production of Welded Engine Frames. (*Machinery*, 31*st January*, 1946, *Vol.* 68, *No.* 1738, *p.* 147, 3 *figs.*)

Methods at the works of Davey, Paxman & Co. Ltd.

Welded Fabrication and Casting. (*The Commonwealth Engineer*, 1*st December*, 1945, *Vol.* 33, *No.* 5, *p.* 147, 8 *figs.*)

A general discussion of techniques and applications with examples of frabricated welded parts.

Welding Chromium-Nickel Steels. (*Welding, February*, 1946, *Vol. XIV, No.* 2, *p.* 80, 9 *figs.*)

Details are given of the metallurgical factors involved in the welding of chromium-nickel steels, with special reference to columbium and titanium stabilized types. Suitable joint preparations and welding techniques are described.

Welding of Nitralloy Steels, by D. Llewellyn. (*Welding, February*, 1946, *Vol. XIV, No.* 2, *p.* 70, 3 *figs.*)

The atomic hydrogen process is perhaps the most satisfactory, but oxy-acetylene gives fair results. Successful experiments have been made in resistance butt welding. Nitralloy steels can be welded by the metallic arc process if suitable electrodes are used, and the procedure is described.

Multiple Resistance-welding, by W. A. Knipe. (*Machinery*, 7*th*, 14*th February*, 1946, *Vol.* 68, *Nos.* 1739, 1740, *pp.* 169 and 201, 17 *figs.*)

This article gives a short survey of machines designed and manufactured for specific jobs, where large outputs have to be maintained at a minimum cost. They can be placed in two main classes: multi-welding machines and automatic indexing machines. Each electrode should be independently supplied with pressure, and methods are described: these include mechanical, hydraulic and compressed air types. Transformer connections and basic electrical design are also described. For timing electronic tube, capacitance and watt-hour meter timers have proved very satisfactory. Usually only one timer per machine is required. Where power supply is limited the machine should be arranged to make welds in sequence which should, if possible, be automatic. Typical assemblies suitable for simultaneous and sequence welding are illustrated and examples of the use of jigs and automatic indexing are given. The main benefits derived from multi-welding machines are: increased production and superior

results obtained by accurate jigging and small distortion ; and a much improved power distribution over all phases of the supply, with less kVA per weld than on normal machines.

Recorded Tests Prove Effective in Maintaining Welding Quality, by John Holden. (*The Machinist, 26th January*, 1946, *Vol.* 89, *No.* 42, *p.* 2289, 6 *figs.*)

Two simple forms are used. One records the effective settings on a given resistance welding machine for a particular operation, and details the test results on weld specimens used to certify the original settings. The second form records the pull test values for specimens welded on each machine at regular intervals.

The Spot Welding of Magnesium, by R. F. Tylecote. (*Welding, February*, 1946, *Vol. XIV, No.* 2, *p.* 74.)

In a review of available literature the author deals with the properties of magnesium, the oxide film and surface preparation before welding, welding conditions, electrodes, mechanical properties and testing, inspection of welds, after-weld protective treatment, and corrosion tests.

Pressure Welding of Light Alloys Without Fusion, by R. F. Tylecote. (*Transactions of the Institute of Welding, November*, 1945, *Vol.* 8, *No.* 4, *p.* 163, 41 *figs.*)

This report described the results of attempts to weld overlapping sheets of nine aluminium and three magnesium alloys by the simultaneous application of heat and pressure at temperatures below their melting points. It was found possible to weld all the alloys to a greater or lesser degree. An aluminium alloy containing magnesium and silicon in the proportions to give Mg_2Si, a duralumin type alloy and an aluminium alloy containing 1¼% manganese, were found to give the best results. Great importance is attached to the effective cleaning of the surfaces. Although recrystallisation had occurred across the interface in many cases, it cannot be said that microscopically visible recrystallisation is a necessary condition for successful welding.

Production Brazing Developments. (*Machinery, January* 17*th*, 1946, *Vol.* 68, *No.* 1736, *p.* 77, 15 *figs.*)

To clear up the confusion existing, the author first defines soldering, brazing, and braze-welding. The differences lie in the temperature of operations, the method of introducing the alloys into the joints, and the analyses of the alloys used. Modern brazing alloys are described.

Butt joints can be brazed and will yield strong connections, but require careful preparation, *e.g.*, clearances of about 0.002″ to 0.003″ must be maintained for maximum strength. Generally speaking, the lap-type of joint proves more economical for production work, since it provides tolerances that can be met with the forming and machining operations commonly employed.

With lap joints clearances of 0.003″ to 0.005″ are best. The depth of lap is usually set at three times the thickness of the thinner member joined. In the case of dissimilar metals, it may be necessary to calculate this value. The factors involved in correct brazing procedure are : (1) cleaning the parts ; (2) fluxing the joint ; (3) application of the alloy ; (4) heating the joint ; and (5) cleaning the finished assembly, and these are discussed.

Cleaning may be accomplished by chemical or mechanical means. The method of applying the brazing alloy and the means of heating the parts to effect flowing of the alloy are determined by the number of pieces involved and the rate of production. One of the principal features of high-production technique is the removal of the personal element by the preplacement of the alloy and the employment of semi-automatic or automatic means of heating, together with some form of conveying system. Features of this process are indicated, and examples are given, including tool manufacture and repair as well as general products.

INDEX TO ADVERTISEMENTS

As a war-time measure the advertisement section of this Journal is now published in two editions, A and B. Advertisers' announcements only appear in one edition each month, advertisements in edition A alternating with those in edition B the following month. This Index gives the page number and edition in which the advertisements appear for the current month.

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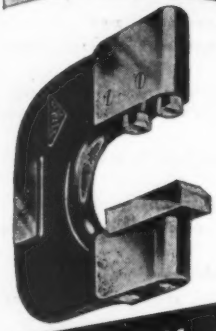

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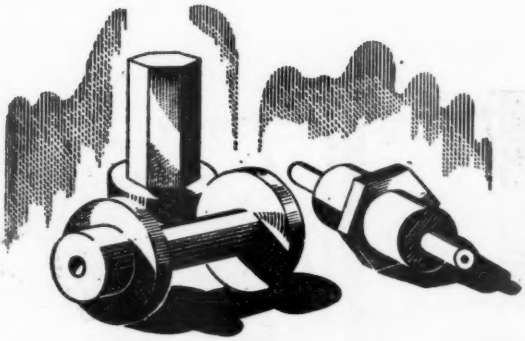

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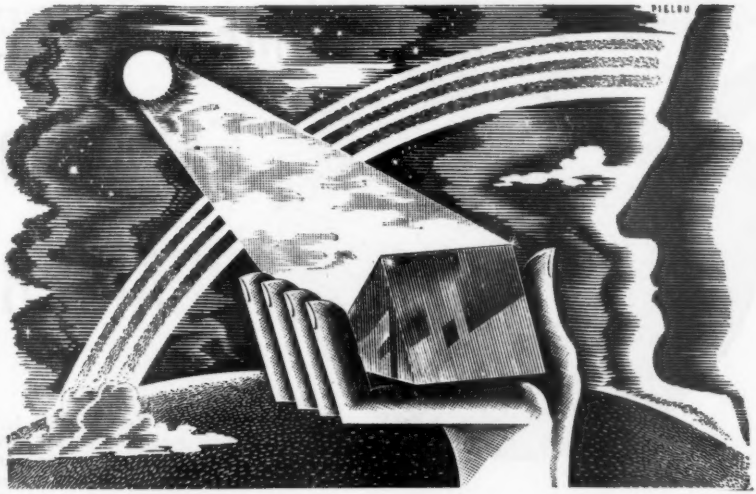

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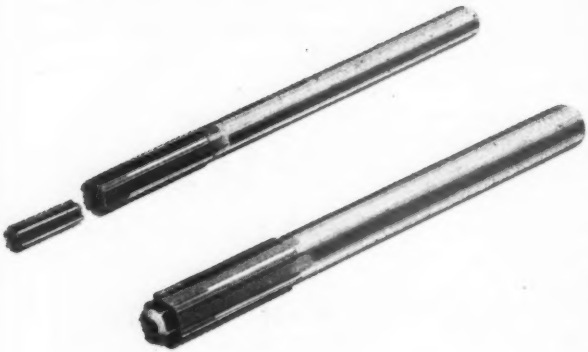

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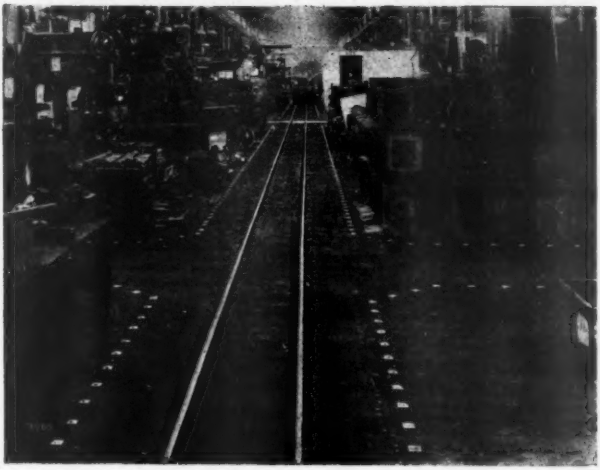

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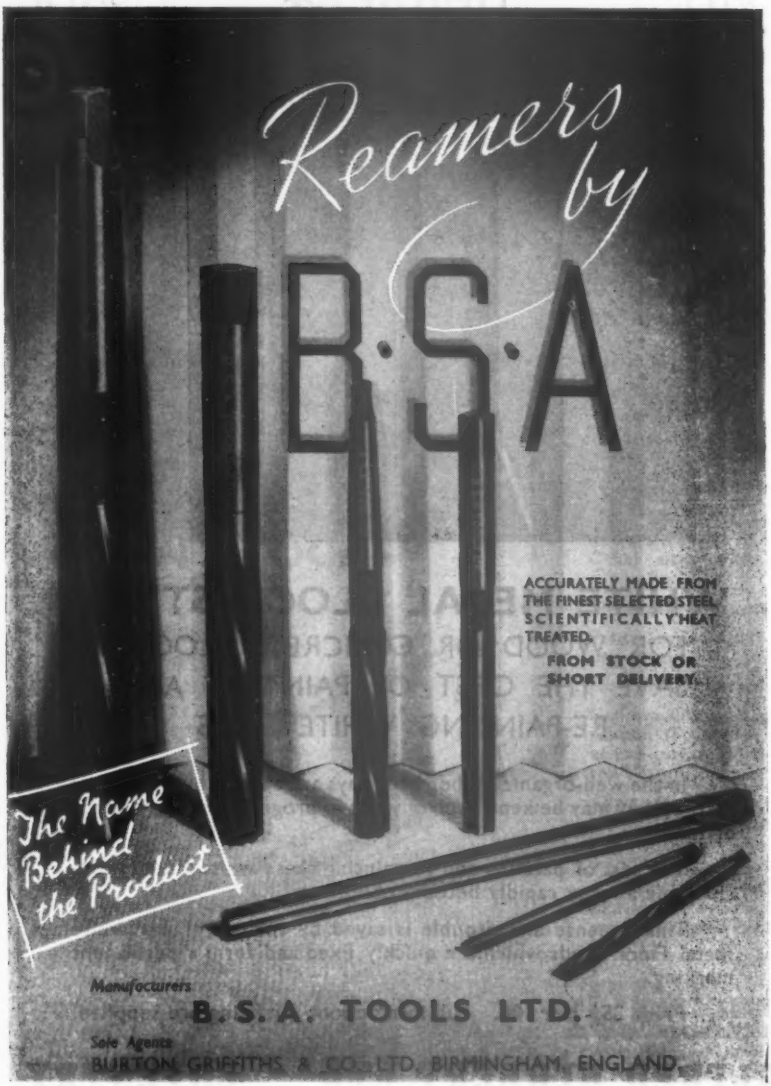
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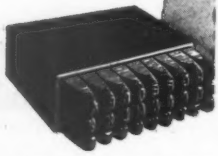

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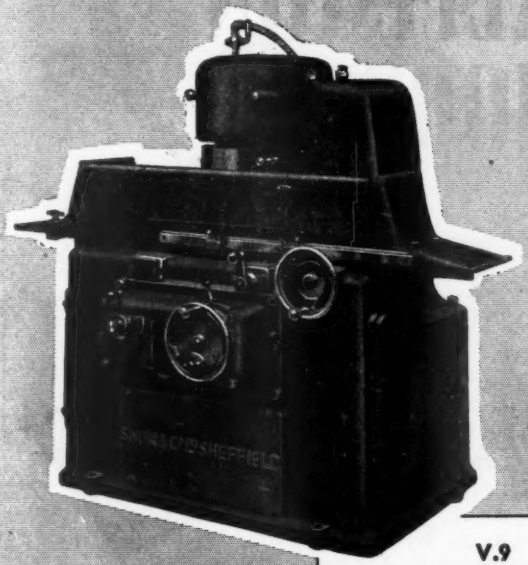

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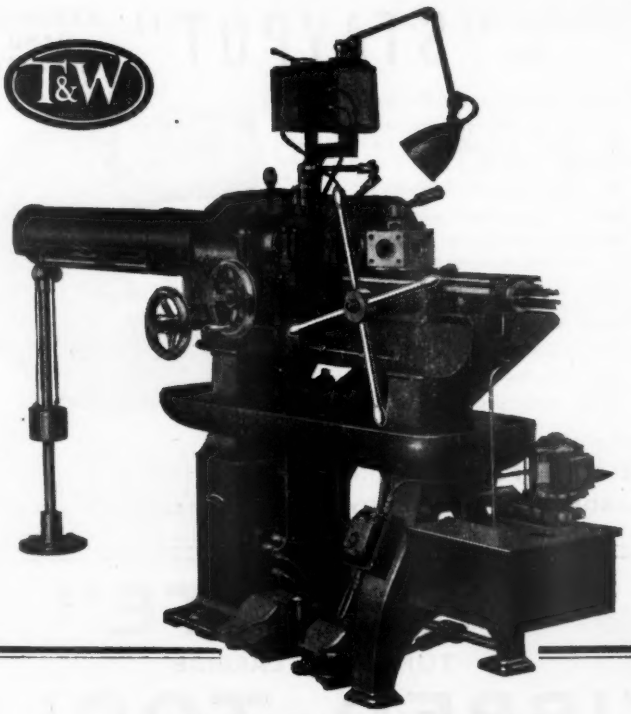

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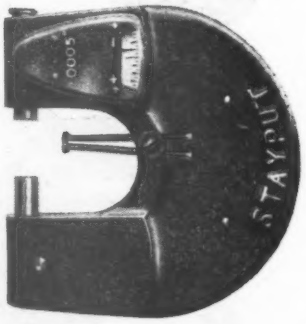

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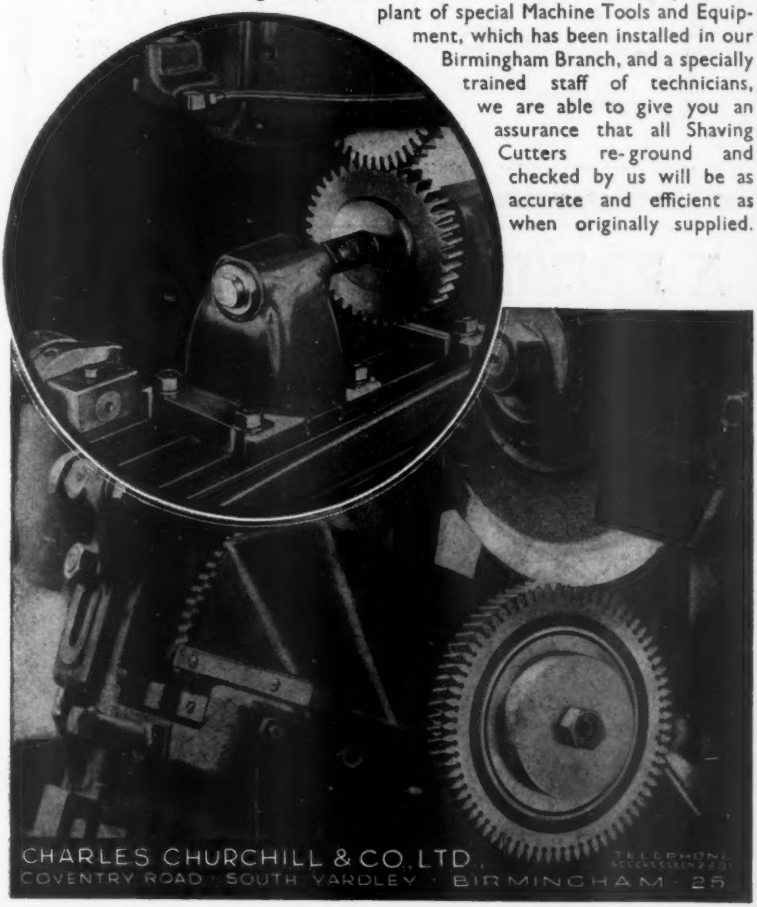

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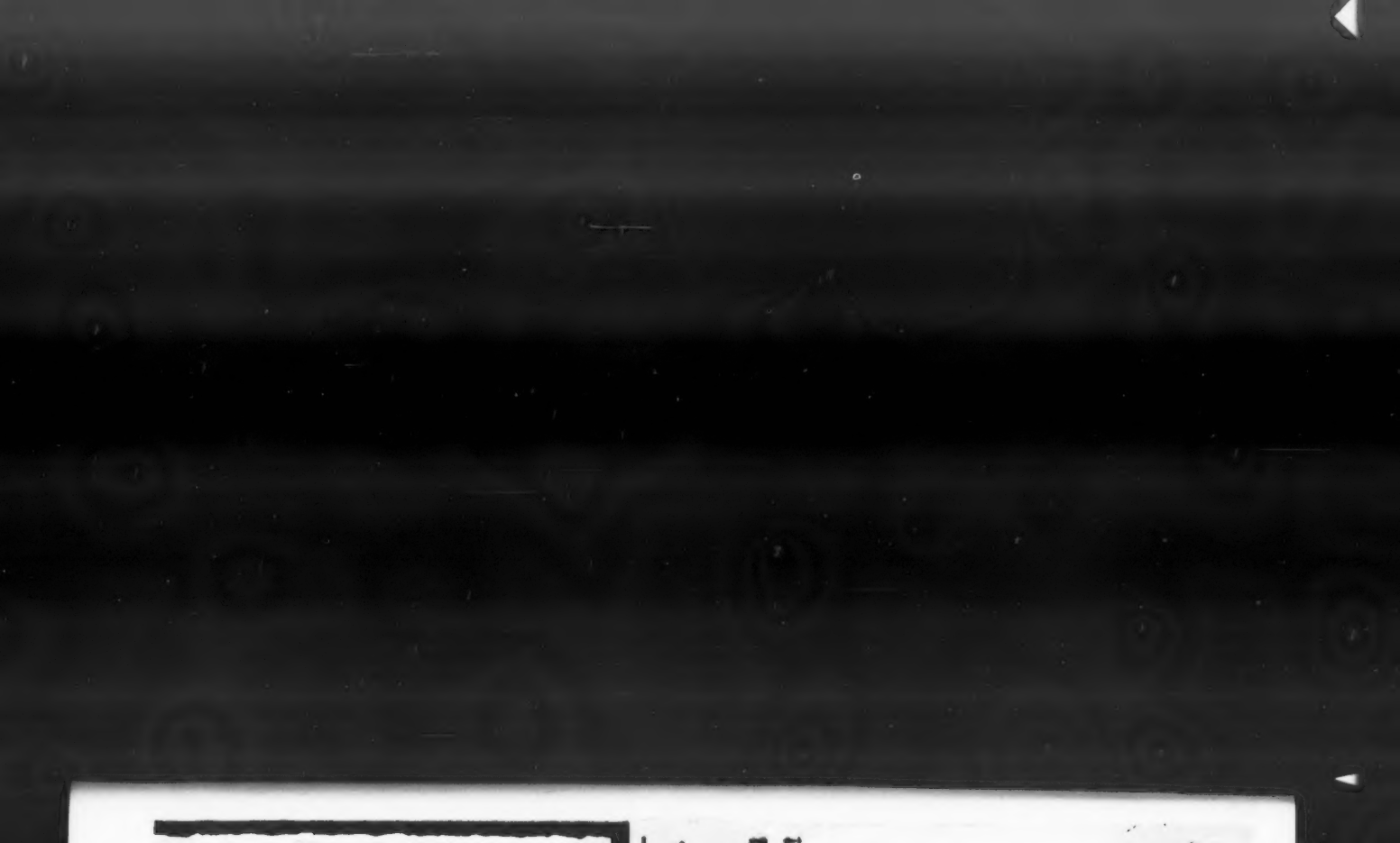

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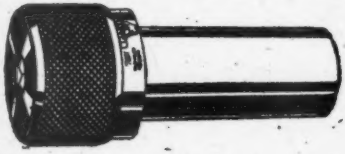

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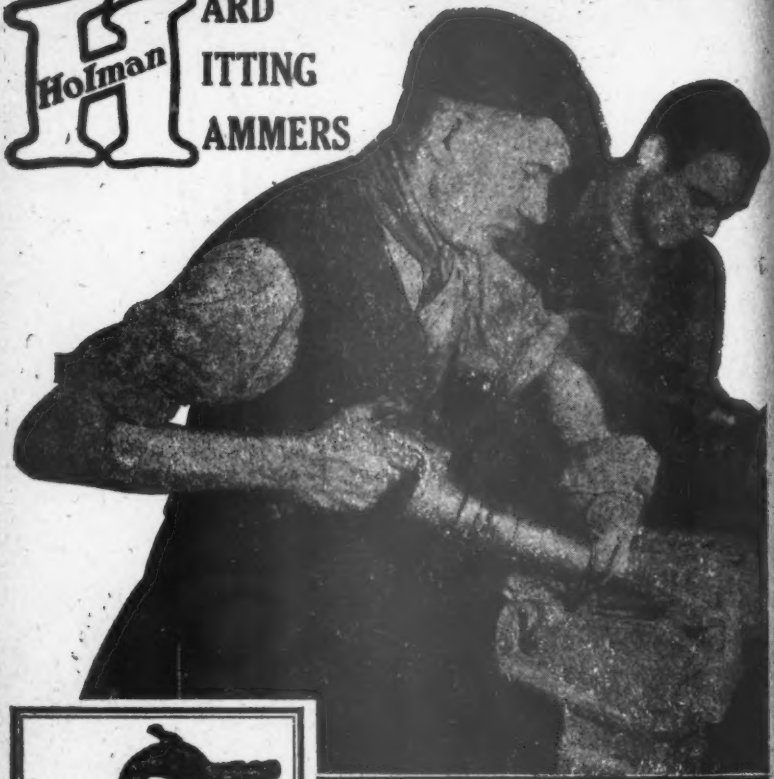

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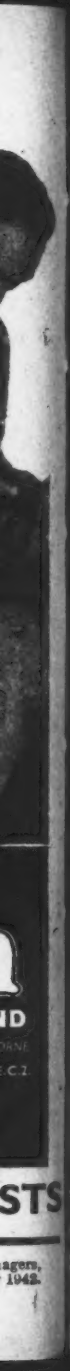
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